The development of Paediatric Endoscopic Surgery

By:

Hock Lim TAN

The Department of Surgery

The Queen Elizabeth Hospital

The University of Adelaide

Submitted April 1999

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text or publication.

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Hock Lim TAN
8th April 1999

Acknowledgment

I would like to thank the following persons who were involved directly or indirectly in the work that has been put into this thesis.

Mr. David Rowan Webb adult urologist at the Royal Melbourne Hospital worked in close collaboration with me both clinically and in the laboratory, to investigate the safety and efficacy of percutaneous renal puncture techniques in small dogs in our initial evaluation of percutaneous nephroscopy in children. Acknowledgment must also be given to Mr. Douglas G. Travis, Adult Urologist also at the Royal Melbourne Hospital Melbourne, who worked with both Mr. Webb and myself on this same study.

Drs. James E Stein, Tracey E Merriman, Azad Najmaldin, Ron Scorpio, Abraham Mammen, Julian Roberts, Osamu Segawa and Joanne Smart were all members of my surgical team who assisted in collecting the raw data and performed the bibliography searches for the publications included in this thesis, hence their inclusion as co-authors in many of my publications.

Several consultant specialist staff at the Royal Children's Hospital were also involved in my publications including Professor John M Hutson (director of the department of surgery), Dr. Keith Waters (paediatric oncologist), Dr. Sam Leung (radiation oncologist), Dr. Damien Grattan-Smith (paediatric radiologist).

Acknowledgment must be extended to my colleagues Mr. Justin H Kelly, Mr. Alan A Woodward, Mr. Russell G Taylor and Mr. Robert Fowler for providing clinical material and support during a critical period in the early phases of the development of Paediatric Laparoscopic Surgery, when there was some doubt expressed on the suitability of minimally invasive procedures in children.

A very special thanks is extended to Mr. Magdi Sourial, animal laboratory manager at the Royal Children's Hospital in Melbourne who had been extremely patient with me when I was undertaking experimental animal work and developing new laparoscopic procedures. Without his expertise, none of my animate experimental procedures would have been possible.

The development of Paediatric Laparoscopic Instruments would not have been possible without the assistance and collaboration of Karl Storz and N Stenning & Company. Cook urology also provided substantial support in helping us develop a whole new range of catheters and stents for use in paediatric endourology.

Lastly but not the least, I would like to thank Professor Guy Maddern my supervisor and Sandra Ireland for providing valuable assistance in preparing this thesis considering that I am not resident in Adelaide.

The Development of
Paediatric Endoscopic Surgery
M.D. Thesis
H.L. Tan

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Part 1

The beginnings of Paediatric Endosurgery

Part 1

The beginnings of Paediatric Endosurgery

Abstract:

This thesis is based on my collective clinical, basic research material and publications in endoscopic paediatric surgical procedures.

The first section traces our initial application of adult percutaneous renal surgical techniques for managing renal calculi disease in children. Having demonstrated clinical success with the technique in older children, it also describes how modifications were made to the technique as a result of experiments performed in our animal laboratory. We discuss the problems of adopting adult instruments and techniques for use in young children, and describe modifications and improvements to the equipment and technique to minimise blood loss, and to facilitate percutaneous renal access in infants and very young children.

The second section describes the introduction to laparoscopic surgery as a result of attending a scientific meeting in London in 1989. It details the development of the first paediatric laparoscopic set by Karl Storz with my assistance. The final part of this section includes my contribution to the medical literature on the topic of paediatric laparoscopic surgery.

The last section is a compilation of my publications on my main focus of interest i.e. paediatric urology, and includes several publications on uretero-pelvic junction obstruction, and the various minimally invasive methods of dealing with this. It also outlines the development of the various procedures described, where relevant.

The summary includes two papers non published works which is included in manuals of paediatric laparoscopic workshops

Introduction: How it started

Mr. David R Webb, adult urologist and to whom I am indebted, introduced me to the concept of Endourology. He had just returned to Melbourne in 1986 after working in the United Kingdom with Professor John Wickham at the Institute of Urology in London, and Professor John Fitzpatrick in Dublin. While in the United Kingdom, he was engaged in some of the pioneering work being developed by Professors Wickham and Fitzpatrick, and had completed a Master of Surgery thesis on lithotripsy.

On his return to Melbourne, he brought with him the knowledge and skills necessary to perform percutaneous nephrolithotripsy in the treatment of urinary tract calculi in adults. It was at that time, a revolutionary method of managing renal calculi in adults. Until the introduction of extra-corporeal shock wave lithotripsy (ESWL) using the HM3 lithotripter by Dornier and percutaneous nephrolithotripsy (PCNL), urinary calculi were managed by open surgery.

I happened to be in attendance at a "grand rounds" presentation by Mr. David Webb on Extra-corporeal shock wave lithotripsy and percutaneous nephrolithotripsy, and came away impressed at the dramatic reduction in the morbidity witnessed in adults treated by these then "new" modalities, when compared to conventional open surgery for renal calculi.

As a paediatric surgeon at the Royal Children's Hospital in Melbourne, I happened to have under my care at that time, several children with urinary tract calculi, and the potential benefits of these using new techniques in managing paediatric patients with urinary calculi was not lost on me. I therefore approached Mr. David Webb to see if he would consider working with me in applying these techniques to paediatric patients. Nothing was known about paediatric endourological applications at that time. There were no reports in the literature on its clinical use in children, but we had a significant numbers of adolescent patients with renal calculus in whom we felt the techniques would be safe, and we started treating these patients to begin with. As confidence grew we started treating younger patients and patients with more complex pathology.

Applying a combination of Extra-Corporeal Shock Wave Lithotripsy (ESWL), Percutaneous Lithotripsy (PCNL) and Uretero-Renoscopy (URS) we successfully managed a total of 23 patients with 27 renal calculi, and published our initial experience with these techniques in 1990.

This lead us to study the various techniques of percutaneous puncture in children from which we developed the technique of single incremental dilatation as published in the British Journal of Urology.

Pediatr Surg Int (1990) 5: 451–453

Pediatric Surgery International

Original article

Management of urinary calculi using endourology and extracorporeal shock wave lithotripsy (ESWL)

D. R. Webb[2], H. L. Tan[1], J. H. Kelly[2], S. W. Beasley[2], R. Fowler[2], and A. Woodward[2]

[1] Department of Surgery, Royal Children's Hospital, Flemington Road, Parkville Victoria 3052, Australia
[2] Department of Urology, Royal Melbourne Hospital, Grattan Street, Parkville Victoria 3052, Australia

Accepted March 5, 1990

Abstract. Childhood urolithiasis is uncommon, comprising 2%–3% of urinary calculi. This paper presents our initial experience in the endourological (EU) treatment of 23 children with urinary calculi presenting to the Royal Childrens' Hospital. Twenty-seven renal, ureteric, and vesical calculi were treated. Three strictures were divided endoscopically synchronously with calculus removal. Twenty-three calculi were renal (6 staghorn, 3 cystine), 2 ureteric, and 2 vesical. In 12 patients (mean age 17.5 years, range 5–24), the underlying cause was a neuropathic bladder secondary to spina bifida. Ten of these had ileal conduits, 1 was successfully undiverted, and 1 previously undiagnosed (all infected). The second group of 11 patients (mean age 10.1 years, range 5–16) had normal renal anatomy. Seventeen (63%) were treated by percutaneous nephrolithotomy (PCNL) or endoscopic lithotripsy via their conduit (n = 1) or bladder (*n* = 2). Three (11%) underwent combined extracorporeal shock wave lithotripsy (ESWL) and PCNL and 7 (26%) were treated by ESWL alone. Twenty-one (77%) were cleared of stone by their primary procedure. Four patients with residual calculi following ESWL have a decreased volume of stone and 2 patients with staghorn calculi treated by PCNL have peripheral fragments only (1 bilateral). There was no mortality or significant morbidity except sepsis in 4 patients, which was treated medically. This series demonstrates that EU and ESWL techniques are safe and effective in children and patients with spina bifida, who often have marked scoliosis, urinary diversion, and difficulties in access. In our experience, paediatric calculi were associated with infection, metabolic disorders, urinary diversion, and patient deformities, and so the majority were more appropriately treated by endourological techniques. ESWL was effective for small stones and in combination with EU for complex stones. By using EU and ESWL alone or in combination, we have avoided open surgery in all patients with urinary calculi treated so far.

Offprint requests to: H. L. Tan

Key words: Percutaneous nephrolithotomy – Lithotripsy – Calculi – Extracorporeal shock wave lithotripsy – Endourology

Introduction

Paediatric urinary calculi are uncommon, comprising 2%–3% of all urinary tract stones [4]. Conventional management has primarily involved open surgery or observation; endoscopic surgery has been reserved for a small minority. Since 1981, the treatment of urinary calculi in adults has undergone a dramatic change with the introduction of extracorporeal shock wave lithotripsy (ESWL) [1], percutaneous nephrolithotomy (PCNL) [8], and ureterorenoscopy (URS) [2]. Alone or in combination, these techniques have reduced the need for open stone surgery to less than 5% of all cases [6]. We have adapted these techniques to children with calculi. This report describes our early experience with these techniques at the Royal Childrens' Hospital, Melbourne.

Patients and methods

Between September 1986 and March 1988, we have treated 27 calculi in 23 patients (Table 1). Three patients had associated stenosis treated synchronously with their calculi by endoscopic division and splintage (Table 2). The patients fell into two groups, those with an underlying neurogenic bladder (all spina bifida) and those with otherwise normal urinary tracts. Twelve patients (8 female, 4 male) had non-neuropathic bladders with a mean age of 10.1 years (5–16), 6 presented with abdominal pain (2 of whom were septic and diagnosed as "acute abdomens"), and 2 had typical "renal colic". Three cystinuric patients had recurrent stones despite active medical prophylaxis with penicillamine.

All patients were evaluated with intravenous urography and ultrasound. There were 23 renal calculi, of which 6 were complete staghorn (struvite) calculi and 3 were cystine stones. One was referred following failed ESWL, another following incomplete open nephrolithotomy and attempted PCNL elsewhere. In the former, the ureteric calculus was wedged above a dense uretero-ileal stricture and an ipsi-lateral renal

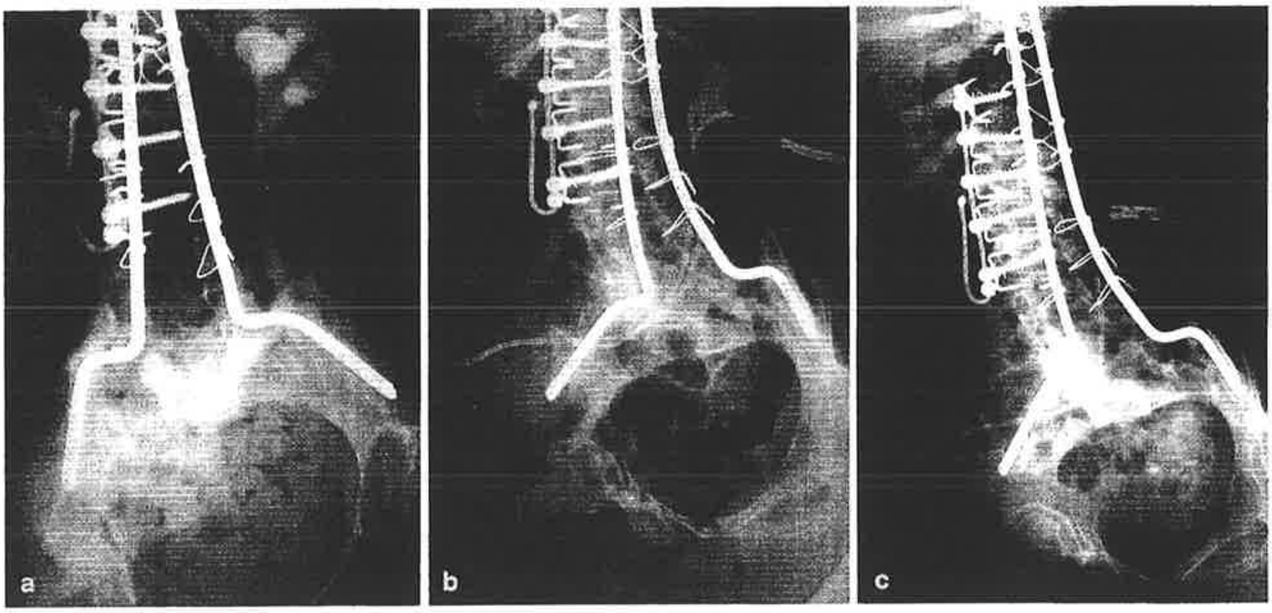


Fig. 1. a Loopogram showing obstructed and dilated left ureter and kidney. **b** Percutaneous nephrostomy and trans-conduit catheters draining obstructed system and demonstrating obstructing left uretero-ileal calculus and staghorn renal calculus. **c** Patient clear of stone following PCNL and endoscopic division of uretero-ileal stricture and removal of ureteric calculus

Table 1. Paediatric endourology

Site of calculi ($n = 27$)	
Renal	23
Ureteric	2
Bladder	2

Table 2. Associated problems

Stenoses	3	Pelvi-ureteric	1
		Uretero-ileal	2
Spina bifida	12	Infection	12
		Ileal conduit	10
		Undiverted	1

calculus as well. The two bladder calculi presented in an infected undiversion and normal bladder, respectively (Table 1).

Patients with small calculi that could be imaged on the lithotripter and in whom distal drainage was unimpeded were treated by ESWL on the Dornier HM3 lithotripter in the standard manner described elsewhere [9]. Treatment was performed under general anaesthesia (GA) with polystyrene lung protection and minor modifications of the gantry using strapping. An average of 1400 shock waves (600–2500) were delivered using ECG triggering at 20 kV. There were no intra-operative complications. Four had double-J stents inserted cystoscopically to prevent subsequent ureteric obstruction.

Larger stones, those associated with poor drainage, those that could not be imaged due to lucency or patient deformity, and those that are known to fragment poorly (2 larger cystine stones) were treated by PCNL with ultrasonic lithotripsy (USL). In the majority this was achieved as a one-stage procedure under GA through a 24/28 French gauge (FG) nephrostomy track. There were 2 patients who had ureteric calculi removed by antegrade extraction at the time of PCNL and by ureteroscopic division of a uretero-ileal stricture (Fig. 1). The bladder calculi were fragmented by an endoscopic stone punch and blind lithotrite, respectively. Table 3 details the numbers of patients treated by each modality. Three large and complex calculi were treated by PCNL and subsequent ESWL to remove small peripheral fragments.

Table 3. Paediatric endourology

	Calculi			
	Treatment			
Technique	Neuropathic (NP)	Non NP	Total	Percent
Endourology (PCNL and URS)	8	4	12	63%
ESWL	3	5	8	26%
Combined (ESWL and PCNL)	1	2	3	11%
Total	12	11	23	

Results

Treatment by ESWL was uncomplicated, all stones achieving satisfactory fragmentation. Patient size was not a problem. There was no pulmonary trauma or excessive bruising. Four patients (2 infective) have residual fragments after 6 months and 1 has required a second treatment due to incomplete fragmentation. There has been no significant colic. Early in the series, percutaneous surgery of large infective staghorn stones and urinary diversions resulted in 4 cases of sepsis (treated medically) and 1 patient required a 2-unit transfusion after bilateral PCNL. There were no other significant complications. Division and splintage for 6 weeks of two uretero-ileal strictures has resulted in permanent patency for over 12 months review. Three patients were left with residual calculi following PCNL. These were all complex infective staghorns in diversions and the remaining fragments were calyceal only. All other patients were cleared by their initial procedure or following supplementary ESWL (n = 3). Two patients (1 cystinuric, 1 struvite) have developed a recurrent stone after initial complete clearance.

Discussion

These early results demonstrate that the new stone treatment techniques developed for adult urolithiasis are safe and effective for the treatment of paediatric calculi and obviate the need for open surgery in the majority of cases. Our experience with ESWL mirrors that of the initial multi-centre American experience [3]. GA allowed excellent patient positioning and avoided movement. One patient with an unrecognised cystine stone had been treated twice by ESWL before referral without evidence of fragmentation. This was easily cleared by PCNL and USL. Few patients with urinary diversions or infection stones were suitable for ESWL due to skeletal deformities, radiolucent stones preventing imaging, or the stones being too large or soft to break satisfactorily. These conditions in our series limited the use of ESWL for the primary management of calculi alone to 7 cases (26% compared to the usual 70% in adults) [7].

EU techniques were more relevant in our series for the same reasons (63%, 17 patients), again demonstrating a reversal of the conventional adult proportion. Our initial theoretical concern of tract size in a paediatric kidney was not borne out by experience, with 24 FG nephrostomies causing no significant complications in patients down to the age of 5 years. In retrospect, this is not surprising as the kidney length was 10 cm in these patients and previous clinical reports [10] and experimental studies in canine kidneys less than 7 cm with similar large-size tracts have not demonstrated renal trauma [5]. Due to quite grotesque anatomical situations, access could not be achieved in all cases percutaneously, including those where ESWL imaging was not possible. Where necessary, conduitoscopy was greatly facilitated by guidewires placed radiologically from above or below pre-operatively to easily negotiate the conduit and define the uretero-ileal region (Fig. 1 abc).

As the majority of paediatric stones have an underlying cause and are likely to recur, these minimally invasive techniques, which may be repeated as necessary, take on even greater significance in the paediatric population by avoiding repeated open surgery and possible nephrectomy and subsequent dialysis.

References

1. Chaussy C, Bredel W, Schmidt E (1980) Extra-corporeally induced destruction of kidney stones. Lancet 2: 1255–68
2. Perez-Castro Ellendt E, Martinez-Pineriora (1982) Urethral and renal endoscopy: a new approach. Eur Urol 8: 117–20
3. Sigmand M, Laudone V, Jenkins A (1987) Initial experience with extracorporeal shockwave lithotripsy in children. J Urol 138: 639–841
4. Sinno K, Boyce WH, Resnick MI (1979) Childhood urolothiasis J Urol 121: 662–664
5. Webb DR, Fitzpatrick JM (1985) Percutaneous nephrolithotripsy: a functional and morphological study. J Urol 134: 587–591
6. Webb DR, Mc Nicholas T, Shitfield HN et al (1985) Extracorporeal shockwave lithotripsy, endourology and open surgery: the management and follow-up of 200 patients with urinary calculi. Annals of the Royal College of Surgeons of England 67: 337–40
7. Webb DR, Payne SR, Wickham JEA (1986). Extracorporeal shockwave lithotripsy and percutaneous renal surgery. Brit J Urol 58: 1–4.
8. Wickham JEA, Kellett MJ (1981) Percutaneous nephrolithotomy. Brit J Urol 53: 297–299
9. Wickham JEA, Webb DR, Payne SR (1985) Extracorporeal shockwave lithotripsy: the first 50 patients treated in Britain. Brit Med J 290: 1188–1189
10. Woodside JR, Stevens GF, Start GL (1985). Percutaneous stone removal in children. J Urol 134: 1166–1167

Concern for younger children

The surgical hardware used in our initial experience was "borrowed" on each occasion from the Department of Urology at the Royal Melbourne Hospital, and even though we stated in our first paper that it was safe to use adult instrumentation and to dilate the tracts in children up to 28Fr diameter, I remained concerned that excessive damage would result to infant kidneys if we made a large hole in a small kidney.

We therefore decided to embark on a series of animal experiments in small dogs to evaluate the damage caused to small kidneys by the dilatation. Initial sacrificial dissections with small dogs indicated that the kidneys were about 6cm in axial length, comparable to infant kidneys, and we felt that this was a reasonable model to study the renal damage, and other problems associated with creating a nephro-cutaneous tract in small kidneys.

At the time of our study, there were several methods of performing a dilatation, the so called Amplatz dilators which are serial dilators that need to be interchanged for larger diameter dilators, radial balloon dilators, and stepped telescoping dilators that pass over a smaller dilator hence avoiding the need for interchange.

It became evident through our clinical experience that none of the methods available then were suitable for use in small kidneys with small collecting systems.

Significant blood loss occurred during the interchange of the Amplatz serial dilators due to loss of the tamponade. The Amplatz serial dilators were therefore thought to be unsuitable for use in small children, when bleeding is an important consideration given the smaller blood volume.

The radial balloon dilator likewise suffered from two problems: the need to change at least once to a larger balloon which again resulted in bleeding during the interchange. The second problem is that the tapered ends of the balloons tended to slip out during inflation, unless it was lying well within the collecting system. Unfortunately, it is difficult if not impossible to leave a sufficiently long length of a radial balloon dilator within a small collecting system.

The serial or telescopic dilators initially appeared to offer the best solution to minimize bleeding because of the fact that the larger dilators were always introduced over the smaller ones, maintaining tamponade. However being stepped, they had a tendency to become dislodged when being passed over the smaller dilator, as the step tended to push the kidney away, especially if the collecting system or kidney is small. An additional problem with the telescoping dilator is that they are very long and cumbersome making them difficult to stabilize during the dilatation.

We knew too, from our clinical experience that infants kidneys are considerably more mobile than adult kidneys so we concluded that we had to devise a better system of dilating the tract.

We approached Cook Urology then headquartered in Melbourne to custom make several new pieces of equipment, and came up with a single stage dilator fashioned like a sharpened pencil tip.

Our animal studies demonstrated that this offered several advantages. Firstly, it minimized the risk of bleeding and accidental dislodgment. Secondly, the process of creating a tract was considerably simplified, as the number of steps required were significantly reduced. Being pencil shaped and sharply tapered, we found that it could be passed over a guide wire without the need to first insert a 8Fr Teflon sheath to guide the dilators, as was necessary with the Amplatz type dilators.

We also demonstrated in the laboratory that by using smaller dilators up to 18Fr, we could create a tract without splitting the kidney.

Our conclusion was that this was the *optimum* method of dilating a tract *regardless* of renal size, and the results of our study were published in the British Journal of Urology.

At the same time, we also began to use the single incremental dilator developed in our laboratory in the clinical setting, in both children *and* adult percutaneous renal surgery, and continue to use them today as the dilators of choice.

British Journal of Urology (1991), **68**, 144–147

Single-increment Dilatation for Percutaneous Renal Surgery: An Experimental Study

D. G. TRAVIS, H. L. TAN and D. R. WEBB

Departments of Urology and Surgery, Royal Children's and Royal Melbourne Hospitals, Melbourne, Australia

Summary—Renal nephrostomy track dilatation is an integral part of percutaneous renal surgery. The traditional method has employed sequential dilators of increasing size, or balloon dilatation. This study used a canine model to investigate the effects of single-increment renal track dilatation to 24 F and compares it with the conventional techniques. Single-increment dilatation proved to be a safe technique with minimal haemorrhage or parenchymal damage and healing at 6 weeks by a fine linear scar. It was as safe as conventional techniques. We believe this study proves that single-stage dilatation is a safe technique for use in humans.

An integral part of percutaneous renal surgery is the dilatation of the track to provide an adequate working channel. Dilatation of the track has usually been performed as a multi-increment procedure, commencing with a needle puncture into the collecting system followed by insertion of a guide wire. Once the wire has been placed, dilatation is performed using multiple incremental flexible exchange dilators (Segura *et al.*, 1983), balloon dilators (Clayman *et al.*, 1983; Reddy *et al.*, 1985) or metal telescoping dilators (Alken *et al.*, 1981; Ekelund *et al.*, 1986). The track was usually dilated to 24 to 30 F. Webb and Fitzpatrick (1985) developed a canine model to study the effect of multi-increment dilatation (MID) on the kidney and demonstrated it to be safe.

Despite this, MID in adults has a number of problems. It is time-consuming, guide wire displacement and kinking during exchanges is possible and bleeding may occur from the untamponaded track between exchanges. Balloon dilatation, while decreasing the number of exchanges, still requires multiple exchanges (Clayman *et al.*, 1983).

Rusnack *et al.* (1982) described a single-increment dilatation (SID) using a dilator with a long ureteric extension of 8 F. Webb (1990) developed a different single-increment dilator, without the ureteric extension, which has proved useful in developing a track in adults for Y-puncture, caliceal divertula and staghorn calculi. Its advantages over MID were that it was possible to perform the dilatation in a confined space, the need for a stable guide wire was less critical, it was fast and there was minimal bleeding.

We have been involved in the adaptation of percutaneous renal surgery to paediatric patients. Two major problems became evident. Firstly, children have a small intrarenal collecting system and hence there is difficulty in establishing and maintaining a guide wire. Secondly, small volume blood loss in children is significant by virtue of their small total blood volume. We believe that SID may help to minimise these problems. This experimental study was performed to evaluate the technique and safety of single-increment dilatation of the kidney.

Materials and Method

A single-increment dilator was manufactured for this study by Cook Urological®. It was made of stiffened PVC, pencil-shaped and fitted snugly over a conventional 0.038 inch diameter guide wire. The leading taper comes to a fine point and is glass polished to reduce friction as it dilates the paren-

Accepted for publication 28 November 1990

chyma. A canine model was used. The animals were given a halothane/N_2O general anaesthetic. The kidney was mobilised via a subcostal incision and delivered through the wound. A 6 F fascial dilator was introduced through the maximum renal convexity into the collecting system. A 0.038 inch diameter guide wire was passed through the dilator into the collecting system and the fascial dilator was removed. The dilatation system of choice was used and the track was dilated to 24 F. After dilatation, a 25 F Amplatz sheath was introduced into the collecting system over the dilator. The kidney was then observed for several minutes and the sheath was then removed. Some kidneys were harvested for immediate evaluation; in other animals the kidney was replaced, the wound closed and the animal awoken. These surviving kidneys were harvested under general anaesthesia at 48 h to study the acute inflammatory response and in others at 6 weeks to study the acute inflammatory response and in others at 6 weeks to study the long-term healing (Table). In this study we compared SID with conventional techniques of dilatation, multi-increment (2 F) Amplatz dilators, balloon dilators and metal telescoping dilators. In the SID group 5 kidneys were evaluated immediately, 4 at 48 h and 2 at 6 weeks. In the conventional dilatation group all were studied immediately. We performed 3 multi-increment dilatations, 2 metal telescoping dilatations and 3 balloon dilatations. The kidneys were evaluated by the following methods: operative observations, intravenous urography (IVU) at 48 h and 6 weeks in the surviving animals, observations of the macroscopic specimen, histological sections stained with haematoxylin and eosin, methyl salicylate sections after latex injection, barium latex angiograms and methyl methacrylate corrosion casts. All animals were cared for in the Animal Research Laboratory at the Royal Children's Hospital. The study protocol was approved by the Royal Childrens' Hospital Animal Experimentation Ethics Committee and we adhered to the National Health and Medical Research Committee of Australia's ethical guidelines for animal research (NHMRC, 1985).

Table Breakdown of Dilatation Techniques and Time of Study of 19 Kidneys

	Time of study		
Type of dilatation	*Immediate*	*48 h*	*6 weeks*
Single-increment	5	4	2
Multi-increment	3	–	–
Balloon	3	–	–
Metal telescoping	2	–	–

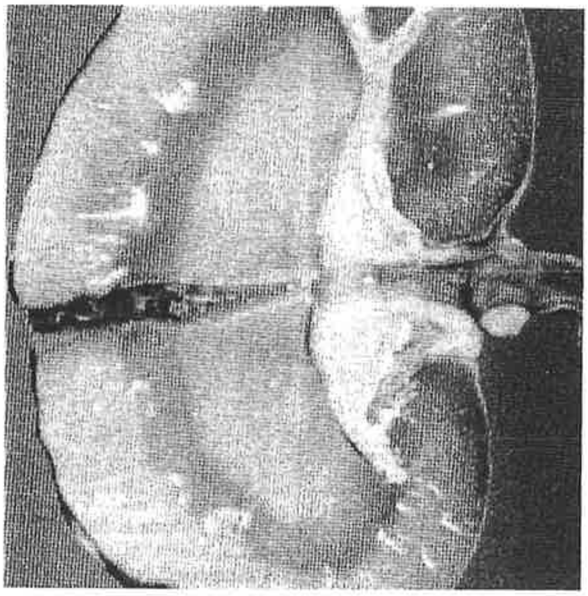


Fig. 1 Macroscopic specimen immediately after single-increment dilatation.

Results

Single-increment dilatation

The operative technique was reproducible and had no complications. It was apparent that rotating the dilator facilitated its' passage through the capsule into the kidney. There was minimal bleeding and no major parenchymal splitting. Macroscopic section of the immediate evaluation kidneys revealed minimal damage in the vicinity of the track (Fig. 1). Microscopic examination demonstrated a thin exudate on the surface of the track with minimal disturbance of the underlying parenchyma. Barium sulphate latex angiograms did not demonstrate any major segmental vessel damage but did reveal minor peripheral vascular damage (Fig. 2). The kidneys evaluated at 48 h demonstrated similar findings except that the track was plugged with blood clot and debris, with a mild inflammatory reaction at the edge of the track. IVU at 48 h using a double contrast infusion technique did not demonstrate any parenchymal or collecting system damage. The kidneys evaluated at 6 weeks were normal, except for a fine radial scar visible on macroscopic and microscopic examination (Fig. 3). Angiograms and IVU were normal.

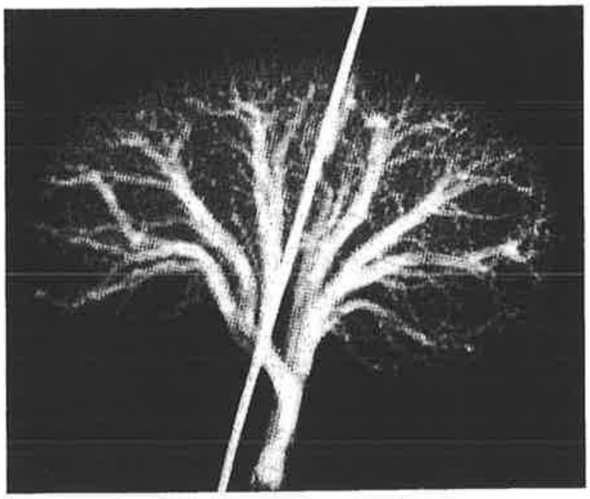


Fig. 2 Barium sulphate latex angiogram immediately after single-increment dilatation. The guide wire was left *in situ* to indicate the track site. A small subcapsular haematoma was present but there was no major vascular damage.

Conventional technique group

Evaluation of this group demonstrated that all 3 of these methods were time-consuming, with mild to moderate oozing occurring between exchanges. The Amplatz sheath was subjectively less stable after MID than in the SID track group. The balloon dilatation technique involved a surprising number of exchanges. The track had to be initially dilated to 8 F to accommodate the deflated balloon. After the balloon had been inflated and deflated, it was also removed and exchanged for a 24 F Amplatz type and sheath in order to position the sheath in the kidney. Mild to moderate oozing occurred between these exchanges. It was observed that in order for balloon dilatation to be effective, the leading 2-cm tip of the inner core of the balloon must be inside the collecting system or the balloon would inflate outside the kidney. Evaluation of these kidneys revealed minimal damage, similar to that following the other MID techniques.

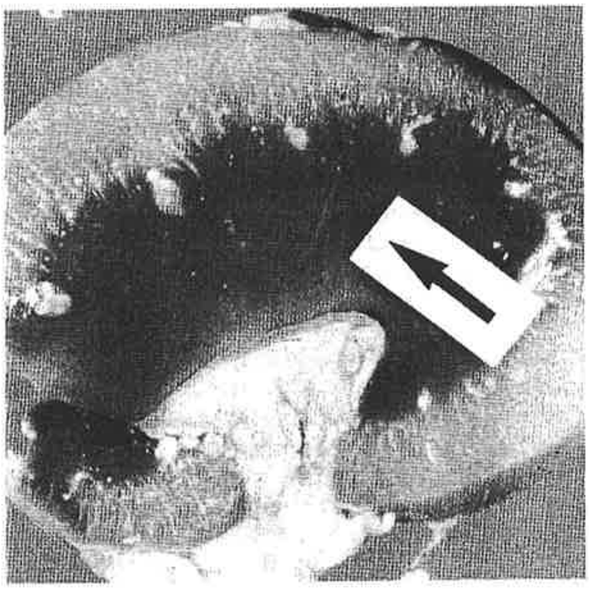


Fig. 3 Macroscopic specimen 6 weeks after single-increment dilatation. The arrow indicates the fine linear scar which was the only evidence remaining of the track.

The metal telescoping dilator technique was simple, although during dilatation it was difficult to control the position metal rod. Bleeding was minimal. These dilators had a flat non-tapered leading edge and the larger dilators caused indentation of the renal capsule before entering the parenchyma, tending to push the kidney away. When performed as a closed procedure this may make dilatation difficult and compromise dilatation where little guide wire is in the kidney. Once again the parenchymal damage was minimal.

Comparison of the damage caused by SID and conventional techniques immediately following track dilatation did not reveal any major differences. No technique caused any major parenchymal splitting or damage to the collecting system.

Discussion

Percutaneous renal surgery is now a well established technique which has acceptable levels of morbidity and mortality (Segura *et al.*, 1983; White and Smith, 1984; Charig *et al.*, 1986; Ekelund *et al.*, 1986; Reddy *et al.*, 1986). Conventional techniques of track dilatation have used either some form of sequential incremental dilator or a balloon dilator. However, these techniques have limitations when confronted with a collecting system with minimal space or where one cannot advance the guide wire to the renal pelvis and ureter, as is often the case with stones in a caliceal diverticulum or a large staghorn calculus. Rusnak *et al.* (1982) described a single-increment dilator and Castaneda-Zuniga *et al.* (1982) reported its' use in 25 patients, dilating the track up to 50 F, in some instances without untoward complications. However, this single-increment dilator had a long leading tip which had to be passed down the ureter; hence it was unsuitable for confined space situations. We have previously developed a single-increment dilator for use in these situations in adults, without significant complications (Webb, 1990). We are now involved in the adaptation of percutaneous surgery to children. A major problem is the physical size of the collecting system, which creates difficulty in establishing and maintaining a guide wire for MID. Single-increment dilatation appeared to be the solution to this problem. In this study we have evaluated the damage caused by a single-increment dilatation to 24 F. We demonstrated that the damage was minimal, both immediately and at 6 weeks, and no major parenchymal splitting occurred. When comparing SID with conventional techniques we found that the damage caused was similar. We did not evaluate any long-term conventional dilatations as the immediate results were identical to those of previous reports which included a 6-week follow-up (Webb and Fitzpatrick, 1985). It was interesting that we gained the subjective impression of less bleeding with the SID technique, which is important in paediatric cases. Certainly the SID technique was the simplest and quickest.

Most paediatric percutaneous surgery can be performed with a 20 or 22 F track and we believe that single-increment dilatation is a safe technique in children. We recommend its use in cases involving compromised or difficult access, gross hydronephrosis, supracostal approach and the majority of paediatric cases. We have now used this method in all cases of adult and paediatric (n = 21) percutaneous renal surgery for the last 18 months.

The technique has been simple and faster than serial dilatations. It has provided excellent tamponaded access to all regions of the kidney without complications, including 2 children under the age of 6 months.

References

Alken, P., Hutschrenreiter, G., Gunther, R. *et al.* (1981). Percutaneous stone manipulation. *J. Urol.*, **125**, 463–467.

Castaneda-Zuniga, W. R., Clayman, R., Smith, A. *et al.* (1982). Nephrostolithotomy: percutaneous techniques for urinary calculus removal. *A.J.R.*, **139**, 721–726.

Charig, C., Webb, D. R., Payne, S. R. *et al.* (1986). Comparison of treatment of renal calculi by open surgery, percutaneous nephrolithotomy and extracorporeal shockwave lithotripsy. *Br. Med. J.*, **292**, 879–892.

Clayman, R. V., Castaneda-Zuniga, W. R., Hunter, J. *et al.* (1983). Rapid balloon dilatation of the nephrostomy track for nephrostolithotomy. *Radiology*, **147**, 884–885.

Ekelund, L., Lindstedt, E., Lundquist, S. B. *et al.* (1986). Studies on renal damage from percutaneous nephrolithotomy. *J. Urol.*, **135**, 682–685.

National Health and Medical Research Council, Commonwealth Scientific and Industrial Research Organization (1985). *Code of Practice for the Care and Use of Animals in Research in Australia.* Canberra: Australian Government Publishing Service.

Reddy, P. K., Hubert, J. C., Lange, P. H. *et al.* (1985). Percutaneous removal of renal and ureteral calculi: experience with 400 cases. *J. Urol.*, **134**, 662–665.

Rusnak, B., Castaneda-Zuniga, W., Kotula, F. *et al.* (1982). An improved dilator system for percutaneous nephrostomies. *Radiology*, **144**, 174.

Segura, J. W., Patterson, D. E., LeRoy, G. *et al.* (1983). Percutaneous lithotripsy. *J. Urol.*, **130**, 1051–1054.

Webb, D. R. (1990). Management of calculi in caliceal diverticula. *Br. J. Urol.*, **65**, 79. (Abstract).

Webb, D. R. and Fitzpatrick, J. M. (1985). Percutaneous nephrolithotripsy, functional and morphological study. *J. Urol.*, **134**, 587–591.

White, E. C. and Smith, A. D. (1984). Percutaneous stone extraction from 200 patients. *J. Urol.*, **132**, 437–442.

The Authors

D. G. Travis, MB, BS, FRACS, Assistant Urologist, Royal Melbourne Hospital.

H. L. Tan, MB, BS, FRACS, Paediatric Surgeon, Royal Childrens' Hospital.

D. R. Webb, MB, BS, MS, DRCOG, FRACS, Urologist and Senior Lecturer in Surgery, Royal Melbourne Hospital.

Requests for reprints to: D. R. Webb, Suite 6, Private Consulting Rooms, Royal Melbourne Hospital, Grattan Street, Parkville, Melbourne, Australia, 3050.

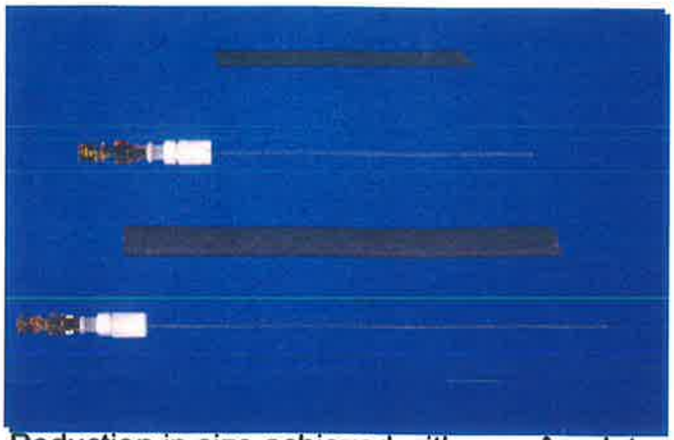
Latest results of Endourological Management Of Urinary Calculi in children

Since our original description, the techniques for endourological management of urinary calculi in children have undergone considerable refinement. Instead of using an adult nephroscope which is 22Fr in diameter, we now use a paediatric operating cystoscope with an offset lens. This telescope has a 5Fr operating channel, large enough to accommodate a ultrasonic lithotripsy probe specially fashioned for us by Karl Storz.

This paediatric cystoscope however has a much shorter working length than the adult instruments, so we had to design correspondingly shorter Amplatz sheaths and stents. Fortunately, Cook Urology being headquartered in Melbourne then were able to assist us in producing a complete range of stents, catheters and dilators suitable for use in very young infants.

Original Adult nephroscope (top) 22Fr
Paediatric Nephroscope (bottom) 18Fr

Infant 11.5Fr Operating cystoscope with
modified 5Fr ultrasound lithotripsy probe

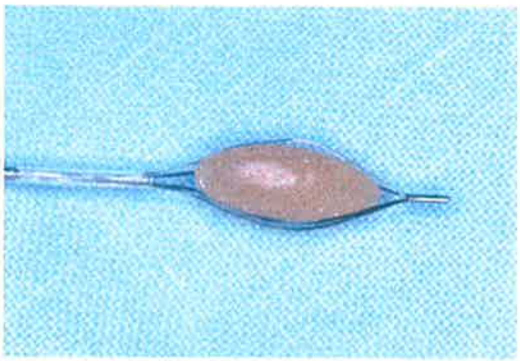


Reduction in size achieved with new Amplatz
Sheaths and puncture needles produced by Cook

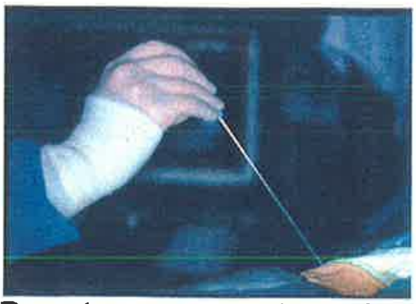
Armed with a complete range of miniaturised equipment, I felt more comfortable performing endourological procedures in young infants, and to date, the youngest child we have successfully operated on is a 16 week old infant presenting with anuria from a Cystine stone obstructing the urethra. In addition, he had an incomplete stag horn calculus in the left kidney.

The urethral stone was removed endoscopically, and the renal function was allowed to improve, before the staghorn was removed using percutaneous nephrolithotripsy.

Xray of 16 week infant
Showing partial L staghorn



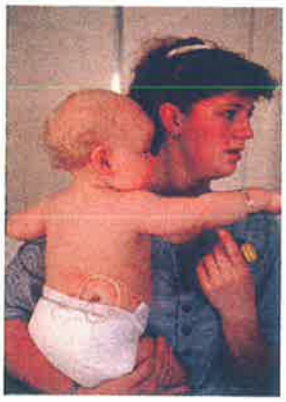
Urethral calculus removed via
cystoscope using snare



Percutaneous puncture of
L Kidney in 16 week old infant
With incomplete cystine staghorn

Figure showing 14Fr Amplatz
sheath in situ during lithotripsy

Complete stone clearance



24 hours post operative

To date, we have treated a total of 63 children with urinary calculi. The results of treatment is as follows:

Modality of treatment* N= 63 (1986 - 1997)		
ESWL	17	27%
PCNL	30	48%
PCNL & ESWL	05	08%
PCNL, ESWL & Chemol	05	08%
Open surgery	03	4.5%
Spontaneous passage	01	1.5%
Chemolysis	01	1.5%
Lap nephrectomy	01	1.5%

As can be seen, and as reported in our first paper, only about one quarter of all paediatric calculi can be treated by ESWL. This experience is also reflected in a series by Losty et al from Dublin who states that only about 25% of their series is suitable for treatment by ESWL. Unlike their series which resorted to conventional open surgery, most of our patients were treated by endo-urological or laparoscopic means.

Of the three children ending up with open procedures, one child had a non functioning kidney with a complete staghorn calculus. This was in the days prior to laparoscopic nephrectomy, and it is likely that this same patient if encountered today would have undergone a laparoscopic nephrectomy.

The second of these patients was a 1.7Kg pre-term baby with a single calculus in an obstructed kidney and underwent open pyelolithotomy and dismembered pyeloplasty. The last patient is one of the most recent patient having been referred to me after two failed open operations for a renal calculus causing obstruction in a solitary right kidney. He presented with a 3cm long impassable proximal ureteric stricture, and has since undergone uretero-calicostomy at which the calculus was removed.

Both of these patients could not have been treated by any other means even in these days of minimal access surgery.

Complications

One child had a two unit transfusion from intra-operative bleeding. This teenager had bilateral complete staghorn calculi and under went bilateral PCNL in one sitting, using conventional serial Amplatz dilators. She was one of the patients at the start of our experience. With the benefit of hindsight, this patient could have been spared the transfusion if we had performed a staged procedure, and if we had used a single stage dilator which at the time of surgery, was still undergoing laboratory evaluation.

Seven patients, all with infective staghorn calculi developed post operative sepsis even though intra-operative antibiotic cover was administered. One of these patients developed endotoxic shock requiring ionotropic support in intensive care unit for 24 hours.

Clearly there is a significant risk of sepsis in patients presenting with infective staghorn calculi when they undergo endourological procedures, even under antibiotic cover.

Reference:

Losty P, Surana R, O'Donnell B. Limitations of extracorporeal shock wave lithotripsy for urinary tract calculi in young children. J Pediat Surg, 1993 Aug;28 (8) 1037 –1039

Further Developments in Minimally Invasive Paediatric Urology

THE URETERO-PELVIC JUNCTION

Having accumulated enough experience with the management of urinary calculi in children, and having incised a few uretero-ileal strictures in patients with ileal conduits and infective renal calculi successfully, I developed an interest in managing uretero-pelvic junction obstruction endoscopically.

Several publications by Dr. H.N. Whitfield and Professor John Wickham had described the technique of percutaneous pyeloplasty or endopyelotomy in adults. None were reported in children. We again approached Karl Storz to produce a sickle shaped reversed cutting cold knife that could be used with an infant resectoscope, and performed endopyelotomies in children.

Again, with the assistance of Cook Urology, a new range of endopyelotomy stents were made by Cook Urology more suited to paediatric patients.

A total of 17 endopyelotomies were performed between 1988 and December 1991, and these results are published.

Our paper is the first description of endopyelotomy in children, and while we have demonstrated that it can be performed safely in children and with comparable results to that reported in adult patients, the success rate was still nonetheless inferior to conventional open dismembered pyeloplasty.

Endopyelotomy requires that the patient has an external nephrostomy to stent the incised ureter for six weeks. While most adults will tolerate this, unfortunately, children do not tolerate external nephrostomies well.

Notwithstanding these limitation, there still exists a place for endopyelotomy particularly for patients with failed open procedure, or if they have an associated renal calculus.

European Urology
Editor: C.C. Schulman, Brussels

Reprint
Publisher: S. Karger AG, Basel
Printed in Switzerland

Pediatric Urology

Eur Urol 1993;24:84–88

H.L. Tan
A. Najmaldin
D.R. Webb

Royal Childrens Hospital and Royal Melbourne Hospital, Melbourne, Australia

Endopyelotomy for Pelvi-Ureteric Junction Obstruction in Children

Key Words
Percutaneous pyeloplasty
Endopyelotomy
Pelvi-ureteric junction obstruction
Open pyeloplasty

Abstract
Endopyelotomy or percutaneous pyeloplasty has become an attractive alternative to open pyeloplasty in adult patients in recent years. However, the experience and reports of this procedure in the paediatric population have been limited to date. We report our experience in paediatric patients undergoing this procedure. Seventeen children with primary (14) or secondary (3) pelvi-ureteric junction (PUJ) obstruction were consented for endopyelotomy over a 3-year period. Patient age ranged from 4 months to 16 years, and the male to female ratio was 11:6. Percutaneous nephrostomy was established in 5 patients prior to endopyelotomy either for diagnosis or for drainage of an acutely obstructed upper tract. The remaining 12 had endopyelotomy as a one-stage procedure. The average duration of the procedure was 103 min (range 60–150 min) and the average hospital stay was 5 days (range 3–9 days). Follow-up averaged 15 months (range 3–36 months). Endopyelotomy was successful in 10/13 patients (77%), unchanged in 1, and failed in the remaining 2. We believe that percutaneous pyeloplasty can be safely and successfully performed in children with primary and secondary PUJ obstruction.

Introduction

Percutaneous nephrostomy has been shown to be effective in the management of upper urinary tract obstruction and infection for many years [1]. In 1976, Fernstrom and Johansson [2] reported the first percutaneous stone removal via a nephrostomy tract. Over the following decade, percutaneous nephrolithotomy became established as the preferred method for extraction of renal stones in both adult and paediatric patients [3–5].

In 1983, Whitfield et al. [6] and Wickham and Kellet [7] described percutaneous endopyelotomy as an alternative to open pyeloplasty in the treatment of pelvi-ureteric junction (PUJ) obstruction. Since then there have been more reports of successful endopyelotomy, predominantly in adult patients, and in small groups of patients [8, 9]. We report our experience in a series of children with both primary and secondary PUJ obstruction managed with percutaneous endoscopic pyeloplasty (endopyelotomy).

Patients and Methods

Between mid 1988 and December 1991, 17 consecutive paediatric patients with PUJ obstruction were consented for endopyelotomy. Three patients had secondary PUJ obstruction following failed open pyeloplasty 18–24 months earlier. The remaining 14 patients had primary PUJ obstruction.

H.L. Tan
Consultant Paediatric Surgeon
The Royal Childrens Hospital
Parkville
Melbourne, Vic 3052 (Australia)

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$2.75/0

Table 1. Patients' demographic data, associated anomalies pre-sperative symptoms, duration of hospital stay and outcome

No.	Age	Site	PUJ obstruction	Associated problems	Presenting symptoms	Pre-op. nephros-tomy	Hospital stay days	Outcome
1	11	R	primary	–	pain + mass	no	–	open pyeloplasty
2	11	L	secondary	mental handicap	urine infection	no	6	success
3	8	L	primary	ipsilateral stones	pain + stones	no	5	success
4	20	L	secondary	mental handicap	pain	no	5	success
5	11	R	primary	–	incidental	no	3	failed
6	6	L	primary	–	urinary infection	no	3	success
7	10	R	primary	non-function. left PUJ obstruction	incidcntal	no	8	no change
8	4M	L	primary	right PUJ	antenatal scan	yes	5	failed
9	14	L	secondary	–	pain	yes	6	success
10	5	R	primary	connective tissue disease	pain + haematuria	no	–	open pyeloplasty
11	13	L	primary	–	pain + pyelonephritis	yes	3	success
12	8	L	primary	–	pain	no	–	open pyeloplasty
13	6	L	primary	–	pain + haematuria	no	9	success
14	5	L	primary	–	urine infection	yes	3	success
15	14	R	primary	–	pain	no	3	success
16	11	L	primary	bilateral VUR	urinary infection	no	4	success
17	15M	R	primary	–	urniary infection	yes	–	open pyeloplasty

Patient demographic data, associated anomalies and preoperative symptoms are tabulated in table 1. The diagnosis of obstruction was based on the results of ultrasound and diuretic DTPA renogram. If doubt existed, a Whittaker test or retrograde pyelogram was performed. The majority also had IVP to demonstrate pelvi-caliceal anatomy (fig. 1).

Five patients had percutaneous nephrostomy established 1 day–3 weeks prior, either for diagnostic or therapeutic management of a dilated system.

A diuretic DTPA and/or IVP was obtained 3 months after endopyelotomy and yearly DTPA thereafter.

Technique

A guide wire is passed retrogradely via a cystoscope into the renal pelvis under image intensifier control. Once the guide wire is positioned within the renal pelvis, a 5-FG angiographic catheter is passed over the guide and its tip positioned within the renal pelvis. A retrograde pyelogram is performed through this catheter using diluted angiograffin, to confirm its position before the catheter is secured to an indwelling Foley catheter to prevent accidental dislodgement.

The patient is turned prone and draped after placing a sponge cushion under the kidney to stabilise it during the operation. A postero-medial calix is identified by performing a retrograde pyelogram using dilute angiograffin with methylene blue added, and the calyx is punctured percutaneously with a 21-gauge Teflon needle. Its position within the collecting system is confirmed by aspirating the blue contrast into a syringe before a tight 'J' guide wire is passed via the Teflon catheter to coil within the renal pelvis. This is performed under image intensifier control at all stages of the procedure.

A nephro-cutaneous fistula is created by dilating over the guide with a single increment dilator with a working sheath [10]. We have found a 16-FG working Amplatz sheath adequate for most infants. Nephroscopy is then performed with an 11-FG cystoscope to identify the angiographic catheter within the renal pelvis which is followed to the PUJ. A guide wire is passed again in a retrograde fashion through the angiographic catheter and externalised by grabbing it as it comes through the pelvic end. The angiographic catheter is then further withdrawn by an assistant so that its tip lies in the upper ureter.

A second antegrade guide wire is then inserted alongside the first under nephroscopic control. If stones are present, they are removed before endopyelotomy. Endopyelotomy is performed by incising the PUJ posterolaterally to avoid damage to renal vessels. We have found the second guide to be extremely useful in 'railroading' the cold knife through the PUJ, as advancing the endoscope between the two guides splays the PUJ wide open, facilitating the passage of the cold knife through what would otherwise be a tight stenosis.

The endopyelotomy is extended onto proximal renal pelvis, and distally until the normal-calibre proximal ureter is identified. On completion of the endopyelotomy, a purpose-built pyelolysis stent with a ureteric tail extending into distal ureter is passed over the guide wire. Our pyelolysis stent has a cope loop lock which when positioned within the renal pelvis prevents accidental dislodgement of the catheter (fig. 2). The proximal end of the pyelolysis stent is brought out as a nephrostomy on free drainage.

A nephrostogram is obtained on the 3rd post-operative day. If there is no extravasation or distal obstruction, the nephrostomy catheter is spigotted, otherwise it is left on free drainage until free drainage of contrast is demonstrated into the bladder. A further nephrostogram is obtained at 6 weeks after surgery prior to removal of the nephrostomy-stent catheter.

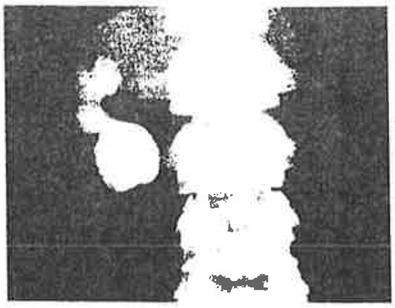


Fig. 1. Preoperative intravenous pyelogram performed on a patient with right-sided primary PUJ obstruction.

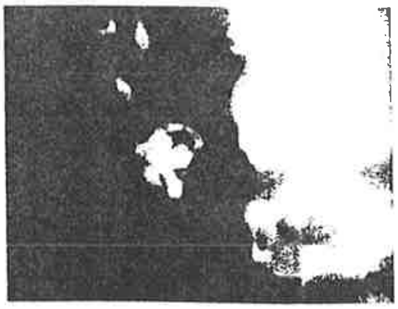


Fig. 2. Pyelolysis stent in situ.

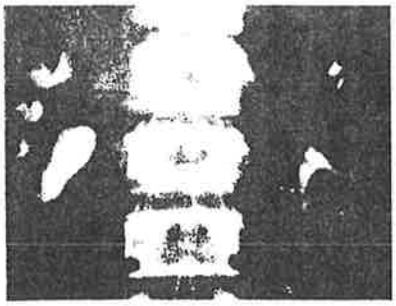


Fig. 3. Post-operative pyelogram performed 1 year following endopyelotomy.

Results

Endopyelotomy was unsuccessfully attempted in 4 patients and open pyeloplasty performed instead. In 3 of these, the guide wire could not be passed through the tight PUJ, and in the fourth, extravasation occurred while establishing percutaneous tract. These patients are omitted from further analysis.

Average duration of the procedure was 103 min (range 60–150 min). We had technical difficulties with two endopyelotomies. In one of these (patient No. 5), the retrograde ureteric catheter dislodged and considerable difficulty was encountered in identifying the PUJ antegradely. This patient had persistent haematuria for 6 weeks for the duration of the nephrostomy. In the other (patient No. 8), difficulty was experienced in placing the nephrostomy stent in the correct position. This patient required repositioning of the nephrostomy stent at 5 days postoperatively. Patient No. 13 developed temporary distal ureteric blockage, presumably due to catheter irritation or oedema at the lower end. This patient required an additional 6 weeks of double J stenting.

The average hospitalisation was 5 days (range 3–9 days), follow-up average 15 months (range 3–36 months). Endopyelotomy was successful in 10 out of 13 patients (77%), unchanged in 1 and failed in the remaining 2 patients. Clinical and radiological evaluation of these patients is shown in table 2. Figure 3 shows the appearance of an intravenous pyelogram 1 year after surgery.

The 2 failed cases were primary obstructions and both had had technical difficulties during the procedure. One had absence of drainage through the PUJ at the post-operative nephrostogram at 6 weeks (patient No. 8), and the second patient showed complete obstruction at the 6-month post-operative DTPA (patient No. 5). Both these patients had subsequent open pyeloplasty with successful results. The previous endopyelotomy did not appear to cause any technical problems at open pyeloplasty.

Table 2. Post-operative evaluation of patients who had successful or unchanged endopyelotomy

No.	Clinical/radiological evaluation		
2	T ½	60–20 min	differential function unchanged
3	T ½	70–20 min	differential function 30–41%
4	T ½	30–10 min	differential function unchanged
6	T ½	39–20 min	differential function unchanged
7	radiology unchanged, clinically asymptomatic		
9	radiology unchanged, clinically asymptomatic		
11	radiology unchanged, clinically asymptomatic		
13	radiology not available, clinically asymptomatic		
14	intravenous pyelogram, excellent drainage		
15	T ½	54–4 min	differential function unchanged
16	T ½	30–15 min	differential function unchanged

T ½ = Half clearance of the DTPA isotope activity from the renal pelvis. Normal < 15 min.

Discussion

The idea of a longitudinal incision into a stenotic ureter and subsequent enlargement of the ureteral calibre with postoperative stenting is not new. Alberran in 1909 and Keyes in 1915 have described a 'urétérotomie externe' [11, 12]. In the 1940s and 1950s, Davis et al. [12] and Davis [13], Oppenheimer and Hinman [14], and

Smart [15] reported their experimental and clinical experience in treating ureteral strictures by direct incision and stenting. However, the technique did not gain popularity until 1983 when Whitfield et al. [6], and Wickham and Kellet [7] described pyelolysis (endopyelotomy) in which the PUJ obstruction was approached percutaneously and incised with a cold knife under direct vision. Since then, more investigators have reported endopyelotomy in the treatment of PUJ obstruction but in relatively small groups of predominantly adult patients [9, 17, 18].

In our group of paediatric patients, we attempted endopyelotomy in 17 cases and had relief of obstruction in 10 (58%). However, allowing for the fact that 4 of our 17 patients did not come to endopyelotomy for the reasons already outlined, 10 of 13 children undergoing endopyelotomy have had a successful outcome. These results are in line with those published previously (64–78%) [8, 17], but not as good as the 87% reported by Karlin et al. [9]. However, these reports were mainly on adult patients.

On the basis of previously published work, there are several factors which may influence the outcome of endopyelotomy [8, 12, 14, 15, 17]. The age of patients, the type of obstruction, the duration of splinting, the size of the splint, the presence of infection and/or stones have all been implicated.

Very little is known about the place of endopyelotomy in the paediatric population, particularly the younger age group. However, Kuenkel and Korth [17] have suggested that older patients are more likely to have good long-term results. In our series, there was a higher failure rate for technical reasons in endopyelotomy in our younger patients. However, a firm conclusion cannot be drawn since the series is too small and has too many variables.

Like previous investigators [8, 9], we have found that secondary PUJ obstruction can be suitably treated by endopyelotomy.

The technique of endopyelotomy we adopted is similar to that described by Ramsey et al. [8] except for our use of a single-increment dilatation [10]. We have abandoned endopyelotomy in favour of an open pyeloplasty if we fail to pass a retrograde guide into the pelvis of the kidney, but others have suggested manoeuvres such as antegrade placement of guide wire via a nephrostomy tract or even retrograde manipulation with a flexible nephroscope [9, 18]. We have not attempted either of these manoeuvres as it has been our experience that the PUJ can be very difficult to identify antegradely in an infant.

It has been suggested that failures of endopyelotomy become evident within 6 weeks after the procedure [2]. We disagree with this since 1 of our patients (No. 5) developed a total PUJ obstruction 6 months after endopyelotomy despite earlier satisfactory tests. Furthermore, secondary obstruction is known to occur years after primary open pyeloplasty.

Endopyelotomy appears to have proved its merit in the relief of secondary PUJ obstruction, especially in those complicated by upper tract stones. However, the value of endopyelotomy in primary PUJ obstruction is less clear. To date, the number of patients treated with percutaneous endopyelotomy is small. In a series of 143 'mainly adult' patients [17], perioperative bleeding that necessitated transfusion occurred in 8%, pneumothorax in 4%; the recurrence rate was 10%. In a retrospective study, Karlin et al. [9] compared 56 endopyelotomies with 32 open pyeloplasties (patients not matched for age, type of disease, time of study), and concluded that the morbidity of percutaneous endopyelotomy was significantly lower than that of open pyeloplasty.

In our study, however, we failed in 4 attempts at endopyelotomy for technical reasons. Two other patients had failed endopyelotomy and in both of these, we experienced perioperative technical difficulties. A further patient required readjustment of the stent. Also, a patient who underwent successful endopyelotomy had a temporary distal ureteral obstruction presumably due to stent irritation or oedema. This patient required an additional 6-week double pig tail stent. In our hands, the average duration of the procedure was not any shorter than an open pyeloplasty. This may be because we are doing a single-stage procedure. Our average hospital stay with endopyelotomy was not significantly less than the average stay for open pyeloplasty.

We admit that this series is small and the follow-up is too brief for firm conclusions to be drawn regarding the role of endopyelotomy in the management of PUJ obstruction in children. However, our early experience suggests that percutaneous endopyelotomy can be safely and successfully performed in children with both secondary and primary PUJ obstruction.

References

1 Goodwin WE, Casey WL, Woolf W: Percutaneous trocar (needle) in hydronephrosis. JAMA 1955;157:891–894.
2 Fernstrom I, Johansson B: Percutaneous pyelolithotomy: A new extraction technique. Scand J Urol Nephrol 1976;10:257–259.
3 Whitfield HH: Percutaneous nephrolithotomy. Br J Urol 1983;55:609–612.
4 Wickham JEA: Percutaneous nephrolithotomy; in Wickham JEA, Miller RA (eds): Percutaneous Renal Surgery. Churchill Livingstone, Edinburgh, 1983, pp 139–147.
5 Woodside JR, Stevens GF, Stark GL, Borden TA, Ball WS: Percutaneous stone removal in paediatric patients. J Urol 1985;134:1166–1167.
6 Whitfield HN, Mills V, Miller RA, Wickham JEA: Percutaneous pyelolysis: An alternative to pyeloplasty. Br J Urol 1983(suppl):93–96.
7 Wickham JEA, Kellet MJ: Percutaneous pyelolysis. Eur Urol 1983;9:122–124.
8 Ramsey JWA, Miller RA, Kellet MJ, Blackford HN, Wickham JEA, Whitfield HN: Percutaneous pyelolysis: Indications, complications and results. Br J Urol 1984;56:586–588.
9 Karlin GS, Badlani GH, Smith AD: Endopyelotomy versus open pyeloplasty: Comparison in 88 patients. J Urol 1988;140:476–478.
10 Travis DG, Tan HL, Webb DR: Single increment dilatation for percutaneous renal surgery: An experimental study. Br J Urol 1991;68:144–147.
11 Murphy LJT: The kidney; in Murphy L.J. (eds): The History of Urology. Springfield, Thomas, 1972, pp 197–208.
12 Davis DM, Strong GH, Drake WM: Intubated ureterotomy: Experimental work and clinical results. J Urol 1984;59:851.
13 Davis DM: Intubated ureterotomy: A new operative for ureteral and ureteropelvic strictures. Surg Gynecol Obstet 1943;76:513.
14 Oppenheimer R, Hinman F Jr: Ureteral regeneration: Contracture versus hyperplasia of smooth muscle. J Urol 1955;74:476.
15 Smart WR: An evaluation of intubation ureterotomy with description of surgical technique. J Urol 1961;85:512.
16 Kadir S, White RI Jr, Engel R: Balloon dilatation in a ureteropelvic junction obstruction. Radiology 1982;143:263–264.
17 Kuenkel M, Korth K: Endopyelotomy: Longterm follow-up of 143 patients. J Endourol 1990;4:109–116.
18 Brannen FE, Bush W, Lewis GP: Endopyelotomy for primary repair of ureteropelvic junction obstruction. J Urol 1988;139:29–32.

Part Two

The watershed

Introduction to laparoscopic surgery

Introduction:
Paediatric Laparoscopic Surgery

Laparoscopic surgery is not new to paediatrics. Dr. Stephen Gans, one of the fathers of paediatric surgery had investigated its use in the late sixties and early seventies, and while he concluded that is was a very useful diagnostic modality, it had limited therapeutic uses. The development of the CT scan and diagnostic ultrasound at about the same time (1970) also heralded a new era in diagnostic capabilities, which allowed the clinician to diagnose intra-coelomic pathology thereby almost completely eliminating the need to perform endoscopic diagnosis. Hence, paediatric endoscopy did not find favour with the exception of three pathological entities, laparoscopy for intra-abdominal testes, cystoscopy to evaluate lower urinary tract pathology, and upper airway endoscopy, particularly for removal of inhaled foreign bodies.

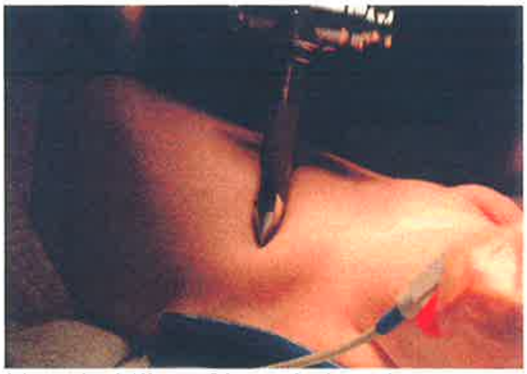
The turning point in paediatric laparoscopic surgery was 1989, when Professor John Wickham invited both Mr. David Webb and myself to the inaugural meeting of the Society for Minimally Invasive Therapy at the Royal Institute in London. It was at this meeting that Drs. Dubois and Perissat showed videos of laparoscopic cholecystectomy, having performed a total of about 200 cases between them.

The significance of this was not lost on me, and at the meeting I enthusiastically approached Mrs. Sybill Storz-Reling of Karl Storz to show me the paediatric laparoscopy set. I was informed that no such set existed except for a simple diagnostic set, because no one was doing any paediatric laparoscopic surgery.

After much discussion with Mrs. Storz-Reling, I was asked to submit some suggestions on the possible new uses of laparoscopic surgery in infants and children and was invited to address the problem of instrumentation available.

The first step clearly is to evaluate existing adult instrumentation, and it was patently clear that adult instrumentation was completely unsuitable because of their size, shape of the bevels, and the type of valves used, which caused excessive gas leak, and hence difficulties maintaining pneumoperitoneum and core temperature.

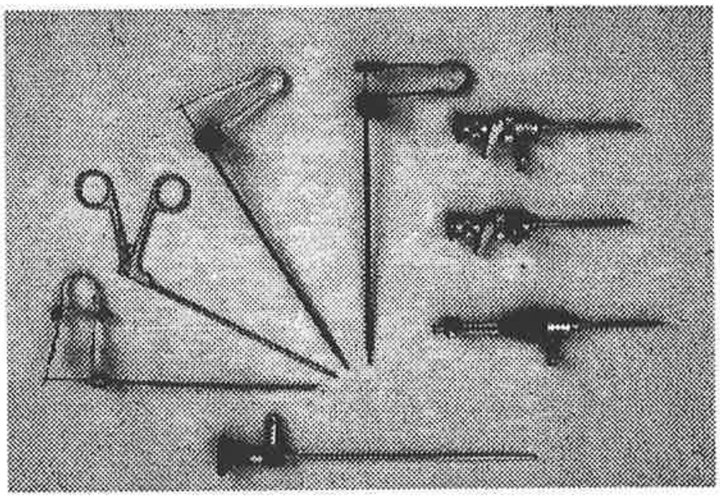
Adult trocar next to an infant!



Unsuitability of bevels in adult trocars

These instruments if used in young children would clearly be dangerous and hardly minimally invasive. The shapes of the trocars and bevels were such that by the time the cannula was inserted so that the bevel is completely in the peritoneal cavity, the tip would have penetrated the posterior abdominal wall structures.

I therefore set about designing a complete new set of instrumentation for Karl Storz, and the quickest way was to review all endoscopic equipment manufactured by Karl Storz and "borrowing" various already existing instruments used in ENT and other specialties and modifying them to make them suitable for use in infants and children.



The "first" paediatric laparoscopic set produced by
Karl Storz with my assistance.

Following a series of submissions, faxes and intense correspondence, the first laparoscopic set was produced by Karl Storz in May 1990, and I was invited to Tutlingen to meet Dr. Karl Storz himself and to be presented with the complete paediatric laparoscopic set.

In January 1990, after I returned from London, I met my colleague Mr. Peter Nottle an adult general surgeon and informed him that some surgeons in Europe were performing laparoscopic cholecystectomy. The significance of this new advance was not lost on him, and he immediately arranged to spend one month with Dr. Dubois.

On his return, he started performing laparoscopic cholecystectomy being one of the first in Australia to perform this new procedure, and I in turn became an observer and assistant learning the new techniques acquired by Mr. Nottle.

Armed with the new laparoscopic set, I then started performing simple diagnostic laparoscopy in infants and children primarily in the diagnosis of intra-abdominal testes, and by 1991, felt that I had developed sufficient skills and dexterity to embark on more complicated laparoscopic procedures.

Infantile hypertrophic pyloric stenosis is a relatively common neonatal condition, and the conventional open procedure for this is very simple. This was a procedure I thought that would lend itself well to being performed laparoscopically. I had also developed the "Tan" endotome and "Tan" pyloric spreader for this operation, and the time was ripe to see if this operation could be performed endoscopically.

Our initial concern was whether the pylorus could be sufficiently well visualized, so I decided to introduce a 4mm 0 degree arthroscope through several open pyloromyotomy incisions and learnt that it was possible to visualize the entire pylorus tumour and the "olive" very well.

We then attempted the first laparoscopic pyloromyotomy in December 1991, a successful attempt. Several patients with infantile hypertrophic pyloric stenosis were then referred to me in quick succession and we were able to repeat our success and published our first paper on laparoscopic pyloromyotomy soon afterwards.

The following is a series of papers on our initial experience with this procedure.

Pediatr Surg Int (1993) 8: 376–378

Pediatric Surgery International

Main topic

Laparoscopic pyloromyotomy for infantile hypertrophic pyloric stenosis

H. L. Tan and A. Najmaldin

Department of Paediatric Surgery, Royal Children's Hospital, Flemington Road, Parkville Melbourne, Victoria 3052, Australia

Abstract. Although great advances in laparoscopic techniques have been made in the field of adult surgery, its application in infants and young children has been limited. We present a technique of laparoscopic pyloromyotomy that has been successfully used in two babies, employing specially made instruments. Laparoscopic surgery deserves further consideration in this age group.

Key words: Laparoscopy – Pyloromyotomy – Pyloric stenosis

Introduction

Laparoscopy was popularised as a diagnostic and therapeutic modality by gynaecologists in Europe. Recently, with the development of laparoscopic cholecystectomy, more interest in minimally invasive surgery has arisen [9, 15]. There are an increasing number of reports of successful laparoscopic appendicectomy, gastric surgery, bowel resection, herniotomy, nephrectomy, and retroperitoneal node dissection in adult patients. The attendant advantages, namely, minimal surgical trauma, minimal scarring, lower morbidity, shorter hospitalisation, and rapid recovery are popular with surgeons and patients. Successful laparoscopic appendicectomy [13] and cholecystectomy [6] have also been reported in children as young as 3 and 7 years of age, respectively.

Widespread application of laparoscopic surgery in infants and young children is lacking, as to date only a few series have been reported worldwide, most of them dealing with diagnostic procedures [1, 4, 8, 11, 14]. The development of operative laparoscopy in infants has largely been impeded by the lack of specialised instruments. The senior author has been working in conjunction with Karl Storz (Tutlingen) in developing a neonatal and infant operative laparoscopic set. We have successfully employed these instruments for an increasing number of surgical procedures. The present report describes a safe and successful laparoscopic technique for the treatment of infantile hypertrophic pyloric stenosis.

Correspondence to: H. L. Tan

Patients and methods

Case 1. A 4-week male infant was admitted with a 5-day history of projectile vomiting and weight loss. The patient was mildy dehydrated and had an easily palpable pyloric tumour. Following resuscitation and with the informed consent of both parents, he underwent a laparoscopic pyloromyotomy. The total operation time was 53 min. The baby was commenced on feeds 12 h later and discharged from hospital 30 h after the pyloromyotomy.

Case 2. A 5-week male infant presented with the typical features of infantile pyloric stenosis, including a palpable pyloric tumour. Laparoscopic pyloromyotomy took 50 min. He was started on feeds soon after returning to the ward and was discharged from hospital 18 h after the surgery.

Technique. The patient is positioned at the foot of the operating table and the surgeon sits at the end, with an assistant on one side and the scrub nurse on the other. The foot of the operating table should be removed prior to positioning the patient to allow easier access for the anaesthetist, who is positioned at the head of the table. The optimal position for the video monitor is directly in front of the surgeon, as this facilitates eye-hand co-ordination.

To create the pneumoperitoneum, we make a 5-mm incision in the upper margin of the umbilicus and pick up the linea alba above the umbilical cicatrix. The linea alba is incised with a no. 11 blade and the peritoneum is picked up between two mosquito artery forceps. A small incision is made in the peritoneum and a pneumoperitoneum established by inserting a 4 mm cannula under direct vision. A 4 mm telescope is inserted and insufflation maintained. A fold of skin is invaginated on either side of the port, and by "sandwiching" the skin together with a 3/0 silk suture on each side we minimise gas leakage and stabilise the port at the same time.

We use an insufflation pressure of 7 cm water, but increase it to 10 cm if necessary. The patient's pCO_2 is constantly monitored, and we have not encountered any anaesthetic or metabolic difficulties at these pressures. Under direct videoendoscopy, the safest point of entry for two

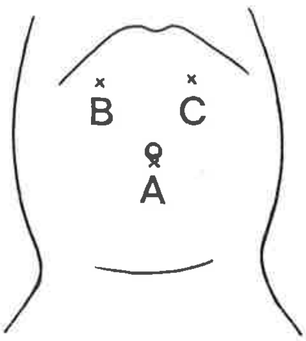


Fig. 1. Three punctures used for laparoscopic pyloromyotomy: **A** Veress needle, insufflation, and video endoscope; **B** pyloric grasper; **C** endotome and pyloric spreader

other 4 mm instrument ports (Fig. 1) are determined taking care to avoid the infant's liver. Two atraumatic graspers are inserted into these two ports and the stomach and pylorus are identified. The first part of the duodenum is grasped just distal to the vein of Mayo by the instrument in the right hand port (Fig. 2 A). The pylorus is then retracted inferiorly away from the overhanging liver, which may otherwise obscure the vision.

An endotome is passed through the left-hand port and a sero-muscular incision made, in the same manner as at an open operation (Fig. 2 B). The endotome is exchanged for the specially built pyloric spreader (Fig. 2 C), and the operation is completed (Fig. 2 D). Air is insufflated into the stomach to exclude an inadvertent mucosal perforation. Mucosal perforations, should they occur, can be oversewn endoscopically. The abdomen is then deflated and steristrips are used to close the micro-incisions.

Discussion

The application of laparoscopy to infants and young children was virtually unknown until 1971, when Gans and Berci investigated and reported the procedure as a safe diagnostic measure [3]. Since that time, the laparoscope has been used by a few surgeons to aid in the diagnosis of hepatobiliary disease, intersex anomalies, and blocked ventriculoperitoneal shunts [4, 8, 11]. Waldschmidt and Schier have recently reported the feasibility of laparoscopic surgery in neonates and infants [14]. In a more recent report, Alain et al. have described the laparoscopic treatment of infantile pyloric stenosis [1].

Our technique of laparoscopic pyloromyotomy differs from that described by Alain et al. We involve one assistant instead of two, and have not found it necessary to use a Palmer's needle to retract the liver. Instead, the trocars themselves can be used as effective retractors while the duodenum is being held with traction inferiorly. The pneumoperitoneum is created with a Veress needle inserted under direct vision through a small periumbilical incision and then replaced by a 4-mm trocar for the telescope. Furthermore, our patients were discharged from hospital 30 and 18 h after surgery, compared with 3 to 6 days in Alain's cases.

Infantile pyloric stenosis is the most common abdominal surgical condition in infancy [10]. The standard treatment is Ramstedt's pyloromyotomy, which is safe and effective. However, open surgery is not without its prob-

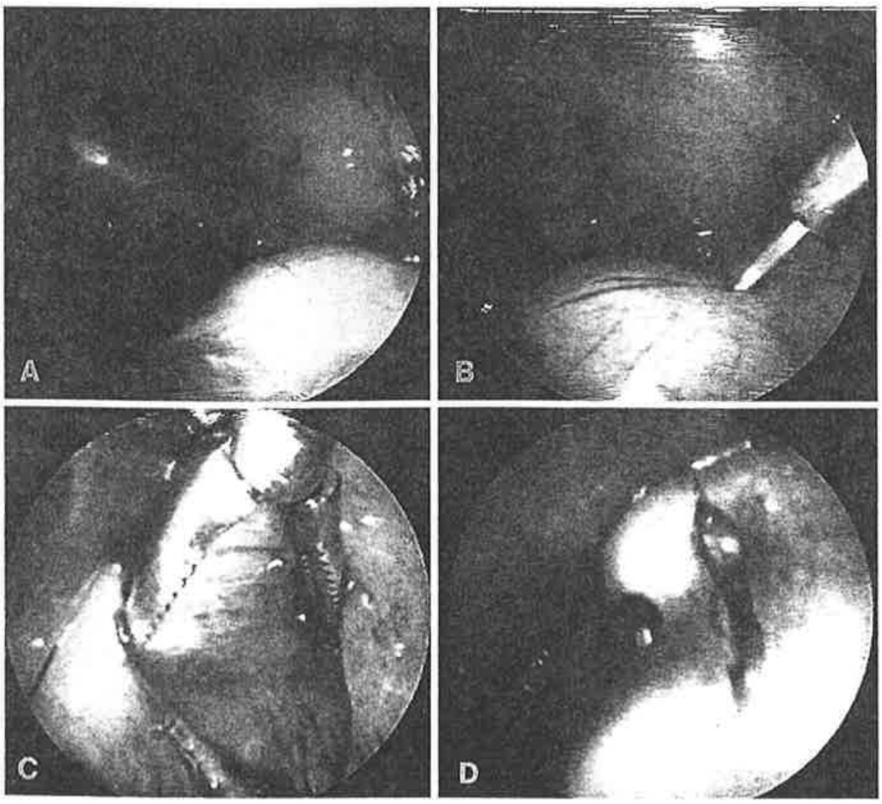


Fig. 2. Intraoperative view of laparoscopic pyloromyotomy. **A** Duodenum grasped just distal to pyloric tumour; **B** Seromuscular incision by endotome; **C** spreading of pyloric tumour; **D** completed myotomy

lems, and wound infection rates of 12% and dehiscence and incisional hernia rates of 3% have been reported [7, 16]. Endoscopic pyloric dilatation using a balloon catheter has been tried, but the results are extremely variable and inconsistent [5, 12]. It appears that laparoscopic pyloromyotomy may become an attractive alternative to open surgery.

Laparoscopy may offer possibilities for facilitating diagnosis and treatment in infants and children. The exposure of the abdominal viscera is excellent and the visual enhancement by the magnifying effect of the telescope is an advantage. The surgical trauma is less severe than in open surgery and bowel handling is minimal. However, meticulous attention to details and proper instruments are essential if it is to be performed effectively and safely. Careful placement of the Veress needle and ports is extremely important, as there is very little room between the site of the puncture and the abdominal viscera even when sufficient pneumoperitoneum is created.

In infants and young children, diagnostic laparoscopy has been shown to be a safe procedure [2]. With the advances in optical systems and miniaturised endoscopic equipment. We believe that therapeutic laparoscopy deserves further evaluation in this age group.

Acknowledgements. The author wishes to thank K. Storz and N. Stenning for assistance in developing appropriate instruments.

Note added in proof

We have performed 20 laparoscopic pyloromyotomy since submission of this paper without modification to the original technique as described.

References

1. Alain JL, Grousseau D, Terrier G (1991) Extramucosal pyloromyotomy by laparoscopy. J Pediatr Surg 26: 1191–1192
2. Gans SL, Austin E (1983) The techniques of laparoscopy. In: Gans SL (ed) Paediatric endoscopy. Grune & Stratton, New York
3. Gans SL, Berci G (1971) Advances in endoscopy of infants and children. J Pediatr Surg 6: 199–233
4. Gans SL, Berci G (1973) Peritoneoscopy in infants and children. J Pediatr Surg 8: 399–405
5. Hayashi AH, Giacomantonio JM, Lau HY, Gillis DA (1990) Balloon catheter dilatation for hypertrophic pyloric stenosis. J Pediatr Surg 25: 1119–1121
6. Newman KD, Marmon LM, Attori R, Evans S (1991) Laparoscopic cholecystectomy in paediatric patients. J Pediatr Surg 26: 1184–1185
7. Rao N, Youngson GG (1989) Wound sepsis following Ramstedt's pyloromyotomy. Br J Surg 78: 1144–1146
8. Rodgers GM, Vries JK, Talbert JL (1983) Laparoscopy in the diagnosis and treatment of malfunctioning ventriculoperitoneal shunt. In: Gans SL (ed) Paediatric endoscopy. Grune & Stratton, New York
9. Sackier JM (1991) Editorial. J Pediatr Surg 26: 1145–1147
10. Spicer RD (1982) Infantile hypertrophic pyloric stenosis: a review. Br J Surg 69: 128–135
11. Stauffer UG (1983) Laparoscopy in hepatology and hepatobiliary diseases. In: Gans SL (ed) Paediatric endoscopy. Grune & Stratton, New York
12. Tam PKH, Carty H (1991) Endoscopy – guided balloon dilatation for infantile hypertrophic pyloric stenosis. Pediatr Surg Int 6: 306–308
13. Valla JS, Limonne B, Valla V, Montupet P, Daoud N, Grinda A, Chavrier Y (1991) Laparoscopic appendicectomy in children: report of 465 cases. Surg Laparoscopy Endoscopy 1: 166–172
14. Waldschmidt J, Schier F (1991) Laparoscopical surgery in neonates and infants. Eur J Paediatr Surg 1: 145–150
15. Wickham JEA (1991) Editorial. Min Invasive Ther 1: 1–5
16. Zeidan B, Wyatt J, MacKenzie A, Brereton RJ (1988) Recent results of treatment of infantile hypertrophic pyloric stenosis. Arch Dis Child 63: 1060–1064

Early Experience With Laparoscopic Pyloromyotomy for Infantile Hypertrophic Pyloric Stenosis

By A. Najmaldin and H.L. Tan
Melbourne, Australia

● The authors report on 37 infants with infantile hypertrophic pyloric stenosis who underwent successful laparoscopic pyloromyotomy. The average age was 6 weeks and average weight was 4.5 kg. Three 4-mm ports were used in each procedure. The average operating time was 29 minutes (range, 7 to 60 minutes). Feeding was begun an average of 5.2 hours (range, 3 to 12 hours) postoperatively, and the average time of discharge was 28 hours (range, 16 to 52 hours) postoperatively. There were no technical failures. One patient had minor surgical emphysema, which resolved spontaneously. Laparoscopic pyloromyotomy can be safe and successful in infants with hypertrophic pyloric stenosis.

INDEX WORDS: Laparoscopy, pyloromyotomy.

INFANTILE hypertrophic pyloric stenosis (IHPS) is a common surgical condition. Until now, the proven safety and effectiveness of open surgical Ramstedt pyloromyotomy in the treatment of IHPS have remained unchallenged. However, open surgery is not without complications; wound infection, dehiscence, hernia, and duodenal mucosa perforation have been reported.[1-3]

In recent years, technological advances have made operative laparoscopy a reality in general surgery.[4-6] However, the application of laparoscopic surgery to pediatrics has been limited.[7-10] In a previous article,[11] we reported on the feasibility and the technique of laparoscopic pyloromyotomy. Since then, we have used this procedure in 37 infants with IHPS.

MATERIALS AND METHODS

The instruments and equipment consist of an infant operative laparoscopic set (Fig 1) that was developed by H.L. Tan in conjunction with Karl Storz (Tuttlingen), a Storz Laparoflator, a high-resolution video monitor, and a high-intensity cold light source.

The procedure is performed with the patient under general anesthesia. The technique is detailed elsewhere.[11] Briefly, it involves carbon dioxide insufflation via a 4-mm port that is inserted under direct vision, using a small periumbilical incision. Two accessory 4-mm ports, one in each upper quadrant, allow for manipulation and straightforward pyloromyotomy. The first part of the duodenum is stabilized with the right upper quadrant atraumatic grasper (Fig 2A), and a seromuscular incision is made with the endotome, through the left upper quadrant port (Fig 2B). The incision is commenced at the duodenal end and is extended proximally; it must be deep enough to accommodate the pyloric spreader (Fig 2C). The mucosa is inspected for inadvertent perforation by injecting air into the nasogastric tube (Fig 2D).

Between December 1991 and July 1993, 37 consecutively treated infants with IHPS underwent laparoscopic pyloromyotomy. The diagnosis of IHPS was confirmed by clinical examination, with or without radiological studies. All fluid, electrolytes, and acid-base imbalances were corrected before surgery. The patients' average age was 6 weeks (range, 3 to 7 weeks) and average weight was 4.5 kg (range, 3.5 to 4.8 kgs). There were 21 male and 4 female patients.

RESULTS

Pyloromyotomy was successful in all 37 infants. There were no technical failures, bleeding, or mucosal perforation. There were no respiratory or anesthetic complications. One patient had minor subcutaneous emphysema around the right upper quadrant port-site postoperatively, which settled spontaneously within a few hours. This was attributed to a minor technical problem with a prototype instrument that has since been modified and has not caused any other problems.

The operating time averaged 29 minutes (range, 7 to 60 minutes). The time between surgery and the first feeding averaged 5.2 hours (range, 3 to 12 hours). Postoperative vomiting was rare, and the average hospital stay was 28 hours (range, 16 to 52 hours).

There were no postoperative wound complications. At the 1-week and 6-week follow-up examinations, all patients were asymptomatic.

DISCUSSION

In 1973, Gans and Berci[7] reported that laparoscopy is a safe procedure for infants, which provides a clear view of the abdominal cavity and a satisfactory means of biopsy and manipulation under direct vision. However, the technique did not gain popularity among pediatric surgeons largely because of a lack of suitable instrumentation. Since then, the development of appropriate instruments and high resolution video monitors has allowed laparoscopic surgery to be performed in a manner not possible previously. To date, there are only three other reports[8,9,12] of the use of laparoscopy in infants; in one of these, it was used in the treatment of IHPS.[9] However, these reports lack details and definitions.

Thus far, our complication rate for this procedure has been minimal. The minor surgical emphysema

From the Royal Children's Hospital, Melbourne, Australia.
Date accepted: March 2, 1994.
Address reprint requests to A. Najmaldin, MS, FRCS, Department of Paediatric Surgery, Level 08–Gledhow Wing, St James's University Hospital, Leeds LS9 7TF, England.

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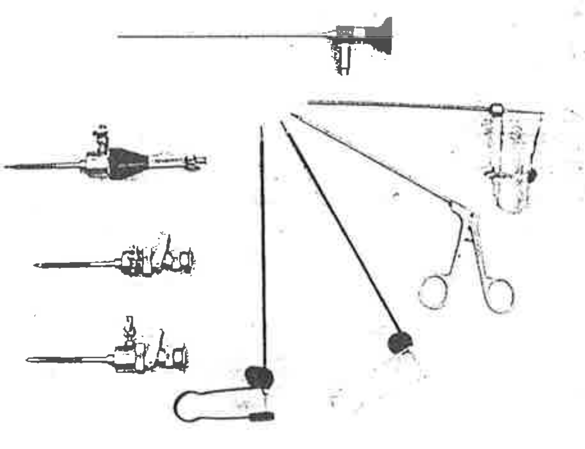

Fig 1. Set of instruments used for pyloromyotomy.

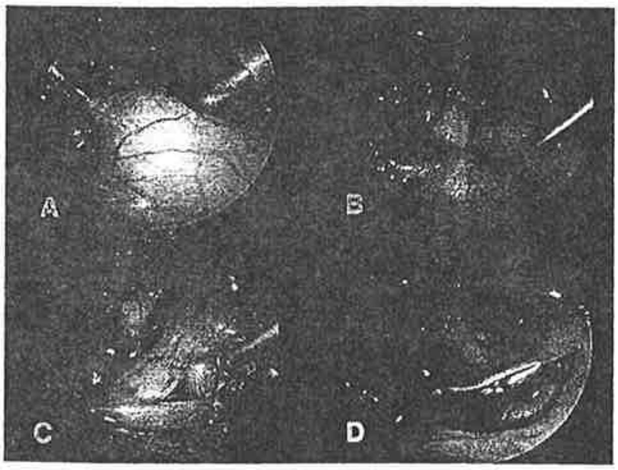

Fig 2. (A) Grasper on first part of the duodenum. (B) Seromuscular incision in tumor. (C) Spreading pyloric tumor. (D) The mucosa is bulging from air insufflated into the stomach via a nasogastric tube.

that occurred in one patient was believed to be related to a technical problem that has since been resolved.

During the early part of the study, the operating time was nearly 1 hour. However, with the increasing experience, the average operating time has been reduced to 15 minutes. The resulting surgical scar is minimal (Fig 3).

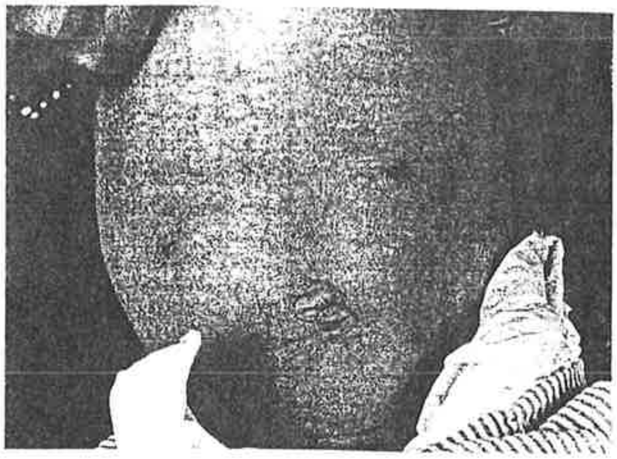

Fig 3. Surgical scar 1 week after laparoscopic pyloromyotomy.

After laparoscopic pyloromyotomy, generally there is minimal postoperative vomiting and a short hospitalization. This may be related to the fact that the operation is performed entirely in situ, with minimal disturbances to the intraabdominal structures. With the open procedure, the stomach and pylorus must be delivered to the outside. However, the differences between these procedures can be established only by a comparative study, which is presently in progress.

This early experience suggests that laparoscopic pyloromyotomy can be safely and successfully performed in infants with hypertrophic pyloric stenosis. However, meticulous attention to detail and proper instruments cannot be over emphasized.

ACKNOWLEDGMENT

The authors acknowledge the assistance of Karl Storz GmbH (Tuttlingen) and N. Stenning in the development of instruments.

REFERENCES

1. Rao N, Youngson GG: Wound sepsis following Ramstedts pyloromyotomy. Por J Gung 78:1144-1146, 1988

2. Zeidan B, Wyatt J, Mackenzie A, et al: Recent results of treatment of infantile hypertrophic pyloric stenosis. Arch Dis Child 63:1060-1064, 1988

3. Bristol JB, Bolton RA: The results of Ramstedts operation in a district general hospital. Br J Surg 63:590-592, 1981

4. Berci G, Shore JM, Parrish J, et al: The evaluation of a new peritoneoscope as a diagnostic aide to the surgeon. Ann Surg 178:37-39, 1973

5. Cuschieri A: Value of laparoscopy in hepatobiliary disease. Br J Surg 61:318-319, 1974

6. Wickham JEA: Minimally Invasive Ther 1:1-5, 1991 (editorial)

7. Gans SL, Berci G: Peritoneoscopy in infants and children. J Pediatr Surg 8:399-405, 1973

8. Waldschmidt J, Schier F: Laparoscopic surgery in neonates and infants. Eur J Pediatr Surg 1:145-150, 1991

9. Alain JL, Grousseau D, Terrier G: Extramucosal pyloromyotomy by laparoscopy. J Pediatr Surg 26:1191-1192, 1991

10. Sackier JM: J Pediatr Surg 26:1145-1147, 1991 (editorial)

11. Tan HL, Najmaldin A: Laparoscopic pyloromyotomy for infantile hypertrophic pyloric stenosis. Pediatr Surg Int 8:376-378, 1993

12. Leape LL, Ramenofsky ML: Laparoscopy in infants and children. J Pediatr Surg 12:929-938, 1977

JOURNAL OF LAPAROENDOSCOPIC SURGERY
Volume 5, Number 2, 1995
Mary Ann Liebert, Inc., Publishers

Pyloromyotomy: Comparison Between Laparoscopic and Open Surgical Techniques

RONALD J. SCORPIO, M.D., HOCK L. TAN, F.R.A.C.S., and JOHN M. HUTSON, M.D., F.R.A.C.S.

ABSTRACT

Several reports have appeared in the literature recently describing various techniques of performing pyloromyotomy laparoscopically. Although there is no doubt that this is now technically feasible, there are unanswered questions with regard to its safety, efficacy, and potential benefits or otherwise to the patient. In an attempt to resolve some of these issues, we compared the results in 37 infants who underwent open pyloromyotomy with 26 who underwent laparoscopic pyloromyotomy. The two groups were similar in terms of sex, age, weight, and presenting pH, although they could not be randomized. The time from feeding to discharge was less for the laparoscopic group (1.4 days) compared with the open group (1.8 days) ($p = 0.04$). Postoperative vomiting was not significantly different between the two groups. The operating time was identical for groups, 29 min vs 27 min. There were 3 complications in the open surgical group and 1 in the laparoscopic group. On the criteria measured, our results suggests that laparoscopic pyloromyotomy is at least as good as conventional surgery, and offers the potential benefits of shortened hospital stay and minimal cosmetic deformity.

INTRODUCTION

FRÉDET AND LESNE IN 1907 PERFORMED the first pyloromyotomy for infantile hypertrophic pyloric stenosis (IHPS) by performing a seromyotomy and closing the defect transversely by the Heineke-Mickulicz method.[1] Ramstedt in 1911 had difficulties closing the muscle defect and had to leave the muscle open and covered the defect with an omental patch.[2] In doing so, he proved that muscle closure was not necessary, and Ramstedt pyloromyotomy became the preferred procedure for treatment of IHPS.

The development of suitable laparoscopic instruments for infants has made it possible to perform pyloromyotomy laparoscopically,[3–5] and we compare the results of 37 infants who have undergone open pyloromyotomy with 26 infants who underwent laparoscopic pyloromyotomy to see if there were any significant differences in the results between the two groups.

MATERIALS AND METHODS

Thirty-seven consecutive infants with IHPS who underwent an open surgical pyloromyotomy at the Royal Childrens Hospital, Melbourne, were compared with 26 consecutive infants who underwent laparoscopic

Department of General Surgery, The Royal Children's Hospital, Melbourne, Australia.
Presented at the Canadian Association of Paediatric Surgeons, Vancouver, September 1993.

pyloromyotomy. It was not possible to randomize the patients, as some surgeons preferred open pyloromyotomy.

Data were recorded prospectively and included age, sex, pH, weight, operating time, time to feed, time from feeding to discharge, length of hospital stay, and degree of postoperative vomiting. Diagnosis of pyloric stenosis was based on history and palpation of the tumor. In cases where the tumor was impalpable, ultrasound was used to confirm the diagnosis. All infants were resuscitated to correct dehydration and any metabolic imbalances.

The open surgical group (group A) underwent conventional Ramstedt's operation, using either a transverse, midline, or umbilical fold incision. This group began full-strength, full-volume feeds 19–24 h after surgery, and prophylactic antibiotics were used intermittently. The second group (group B) underwent laparoscopic pyloromyotomy. Group B was commenced on full-strength, full-volume feeds on demand, at an average of 7 h after surgery. All patients in this group were administered one dose of prophylactic cefazolin at induction. Postoperative vomiting in both groups was classified according to the Spitz scale.[6]

Student's t-test and Fisher's exact test were used to compare the two groups.

Technique of laparoscopic pyloromyotomy

The technique of laparoscopic pyloromyotomy used in our institution has been described previously[4,5] and has not been modified since the original description. The telescope is inserted via a 4-mm cannula inserted through a periumbilical open incision in the linea alba, and two additional 4-mm cannulas are inserted into each upper quadrant of the abdomen after insufflation of the abdominal cavity. Atraumatic grabbing forceps are introduced into each of these upper quadrant ports, and the tumor identified by retracting liver away from the pylorus, grabbing the first part of the duodenum, and retracting it inferiorly, away from the overhanging liver edge.

Pyloromyotomy is performed with a special purpose-built endotome, and the operation is completed by splitting the tumor with an endoscopic pyloric spreader. Mucosal integrity was checked by injecting 30–50 mL of air via a nasogastric tube to distend the stomach while watching the mucosa pout. The abdomen was desufflated, the line alba was closed with a pursestring suture, and steristrips were used for skin apposition at the secondary puncture sites.

RESULTS

The open surgical group, group A, consisted of 33 males and 4 females, with a mean age of 4.55 weeks and a mean weight of 3.88 kg (Table 1). The laparoscopic group, group B, had 21 males and 5 females, with a mean age was 5.1 weeks and a mean weight of 4.01 kg. There were no significant differences in the demographic data of the two groups.

Mean anesthetic time for group A was 27.3 min, and anesthetic time for group B was 29 min. The difference between time of operation and onset of feeds was significant, with group A being 21.2 h and group B being 7.3 h. The time from feeding to discharge was 1.8 days in group A and 1.4 days in group B (p = 0.014). Mean hospital stay for group A was 4.2 days and for group B was 3.8 days ($p > 0.05$) (Table 2).

It should be noted the patients in group B were discharged sooner after surgery. They were commenced on feeds earlier, and the time from feeding to discharge was also significantly shorter. The postoperative stay for group A was 63.4 h compared with 40.9 h for the group operated on via the laparoscopic route.

TABLE 1. DEMOGRAPHIC DATA

	Open procedure	*Laparoscopic procedure*	*p value*
Age (weeks)	4.55 ± 2.29	5.15 ± 2.20	NS
Weight (kg)	3.88 ± 0.69	4.01 ± 0.87	NS
pH	7.46 ± 0.06	7.49 ± 0.73	NS

TABLE 2. OUTCOME DATA

	Open procedure	*Laparoscopic procedure*	*p value*
Operating time (min)	27.3 ± 10.4	40.2 ± 19.4	0.004
Time to feeds (h)	21.2 ± 3.0	7.3 ± 5.0	0.000
Time from feeds to discharge (days)	1.8 ± 0.6	1.4 ± 0.7	0.014
Hospital stay (days)	4.2 ± 1.5	3.8 ± 1.7	NS

There were 3 complications in group A, 2 wound infections and 1 wound dehiscence. None of these 3 patients had received prophylactic antibiotics. In group B there was 1 complication, an infant who developed subcutaneous emphysema, which resolved after 6 h with no ill effects. The complication rate was not significantly different between the two groups. Postoperative vomiting was measured by the Spitz scale. Group A had 27 patients in category 1 (no vomiting) and 10 patients in category 2 (an occasional vomit). In group B, there were 16 patients in category 1 and 10 patients in category 2. There was no statistically significant difference between the incidence of postoperative vomiting in the two groups (Table 3).

DISCUSSION

This study demonstrates that laparoscopic pyloromyotomy is as safe as conventional open surgery for IHPS. There does not appear to be any statistically significant differences in the complications between the two groups, although the number of patients is still small. However, it can be argued that the risk of wound dehiscence is eliminated altogether by a laparoscopic approach. It can also be argued that any wound sepsis following laparoscopy would have far less serious consequences. A confounding factor is that all the laparoscopic patients received prophylactic antibiotics. The rationale for this is that the incision is in the umbilical fold, which is known to be a major source of pathogenic organisms. Therefore, such patients are particularly at a higher risk of wound infection.

Laparoscopic pyloromyotomy can be performed in the same amount of time as the open procedure in our series. With a fully trained and organized team, it can take as little as 7 min to perform the procedure laparoscopically from incision to skin closure, as was the case with 1 patient in this series, and laparoscopic pyloromyotomy could evolve as the quicker of the two procedures if time is an issue.

Although there is no statistically significant difference in the postoperative vomiting between the two groups, we were able to commence feeds much earlier in the group undergoing laparoscopic pyloromyotomy. Scharli and Ledischke[7] have demonstrated that normal gastric peristalsis does not return for at least 24 h after open pyloromyotomy, and they attributed this to gastritis. However, we challenge this view and believe that gastric aperistalsis is the result of the handling of the stomach required to deliver the tumor through the wound using conventional pyloromyotomy. Laparoscopic pyloromyotomy can be performed entirely in situ and avoids needless handling.

An important consideration is minimization of the physical trauma and deformity from surgery. There can be no doubt that laparoscopic pyloromyotomy offers significant cosmetic improvement over conventional pyloromyotomy. Tan and Bianchi[8] reported pyloromyotomy through a periumbilical incision, and although it offers similar cosmetic advantages, it is our experience that it can be difficult to deliver the tumor, and there is significantly more trauma to the stomach from the traction required to deliver it with this approach. Bianchi's method does not eliminate the risk of wound dehiscence.

TABLE 3. POSTOPERATIVE VOMITING

Spitz scale	*Open procedure*	*Laparoscopic procedure*	*p value*
1	27	16	NS
2	10	10	NS

This study demonstrates that laparoscopic pyloromyotomy is as safe as conventional surgery. It offers the advantages over conventional surgery of significantly reduced postoperative stay, no risk of dehiscence, and minimal cosmetic deformity. Ideally, a randomized, controlled trial would be the optimal way to evaluate the two procedures. However, this pilot study has demonstrated that there may be an advantage to performing the procedure laparoscopically.

ACKNOWLEDGMENTS

We wish to acknowledge the assistance of Mr. J.H. Kelly, Mr. A.W. Woodward, and Mr. R.G. Taylor for providing us with the clinical cases that were included in this study. We also acknowledge that data from the 37 patients used in our control have been used and published in a review of open pyloromyotomy results by Drs. Scorpio and Beasley.[9] However, the previously published article has no relevance to the thrust of this article.

REFERENCES

1. Fredet P, Lesne E: Stenose du pylore chez le nourisson. Resultat anatomique de la pylorotomie sur un cas traite et gueri depuis 3 mois. Bull Mem Soc Nat Chir 1908;54:1050.
2. Ramstedt C: Zur operation der angeborenen pylorus stenose. Med Klin 1912;8:1702.
3. Alain J, Grousseau D, Terries G: Extramucosal pyloromyotomy by laparoscopy. J Pediatr Surg 1991;26:1191–1192.
4. Tan HL, Najmaldin A: Laparoscopic pyloromyotomy for infantile hypertrophic pyloric stenosis. Pediatr Surg Int 1993;8:376–378.
5. Tan HL: Laparoscopic surgery in children and infants. In: Graber JN, Schultz LS, Pietrafitta JJ, Hickok FD (eds). Laparoscopic Abdominal Surgery. New York: McGraw-Hill, 1993, pp 327–338.
6. Spitz L: Vomiting after pyloromyotomy for infantile hypertrophic pyloric stenosis. Arch Dis Child 1979;54:886–889.
7. Scharli AF, Ledischke JF: Gastric motility after pyloromyotomy in infants: A reappraisal of postoperative feeding. Surgery 1968;64:113–117.
8. Tan KC, Bianchi A: Circumumbilical incision for pyloromyotomy. Br J Surg 1986;73:339.
9. Scorpio RJ, Beasley SW: Pyloromyotomy: Why make an easy operation difficult? J R Coll Surg 1993;38:299–301.

Address reprint requests to:
Mr. H.L. Tan
Gleneagles Medical
Centre #03-03
6 Napier Road
Singapore 102S

Further developments in Paediatric Laparoscopic Surgery

Although there was indeed general intrigue, outcry and concern about the introduction of laparoscopy into paediatric surgery by many of the elder statesmen of paediatric surgery (like there was initial resistance to laparoscopic cholecystectomy), there was equally, considerable interest expressed by many paediatric surgeons in these new laparoscopic procedures that were being introduced in paediatric surgery and paediatric urology.

With increasing demands for workshops, I conducted the first international workshop on paediatric laparoscopic surgery at the Royal Children's Hospital in 1992. This was attended by a large number of delegates from Australia and overseas.

In the ensuing years, several "new" procedures were developed, and form the basis of the next set of published papers, including a chapter in an book on adult laparoscopic surgery.

Among this set of publications are the first known reports of laparoscopic adhesiolysis, ovariopexy, thoracic vertebral biopsy and cysto-prostatectomy in paediatric patients.

Pediatr Surg Int (1993) 8: 379–381

Pediatric Surgery International

Main topic

Laparoscopic ovariopexy for paediatric pelvic malignancies

H. L. Tan[1], R. J. Scorpio[1], J. M. Hutson[1], K. Waters[2], and S. Leung[3]

[1] Department of Surgery and
[2] Division of Haematology-Oncology (Department of Paediatrics), The Royal Childrens Hospital, Parkville VIC 3052, Melbourne, Australia
[3] Department of Radiation Therapy, Peter MacCallum Cancer Institute, Melbourne, Australia

Abstract. Ovariopexy can prevent radiation damage to the ovaries in children undergoing pelvic irradiation, and should be considered prior to radical curative radiotherapy. We report two children who have had successful laparoscopic ovariopexy, and advocate its use in conjunction with local radiotherapy in childhood malignancy. It reduces iatrogenic trauma significantly and assists with staging and managing paediatric pelvic malignancies.

Key words: Laparoscopy – Ovariopexy

Introduction

The management of paediatric malignancies has undergone significant changes in recent years, tending away from radical extirpative surgery to a more conservative approach [3]. Chemotherapy, combined with local radiotherapy and limited excision, has allowed conservation of function without compromising the success of therapy in pelvic malignancies of childhood [4].

A major morbidity associated with pelvic irradiation is ovarian ablation [1]. This can be prevented by ovariopexy, which reduces the radiation dose to the ovary. We report two successful cases of laparoscopic ovariopexy in children and advocate its use in children requiring pelvic irradiation. The benefits in children undergoing multimodal therapy are discussed.

Case reports

Case 1. A 2-year-old girl (16.2 kg) presented with a history of itching and soreness of the labia. A polypoid mass was seen protruding from the vaginal opening, and pelvic ultrasound confirmed the presence of a midline mass behind the bladder. A biopsy of this lesion confirmed the diagnosis of a rhabdomyosarcoma. She was started on chemotherapy consisting of vincristine, cyclophosphamide, and adriamycin. There was an excellent clinical response to this regime, with macroscopic disappearance of the tumour. It was decided that localised radiotherapy would be given in lieu of extirpative surgery. Iridium curietherapy was advocated, and was combined with laparoscopic ovariopexy.

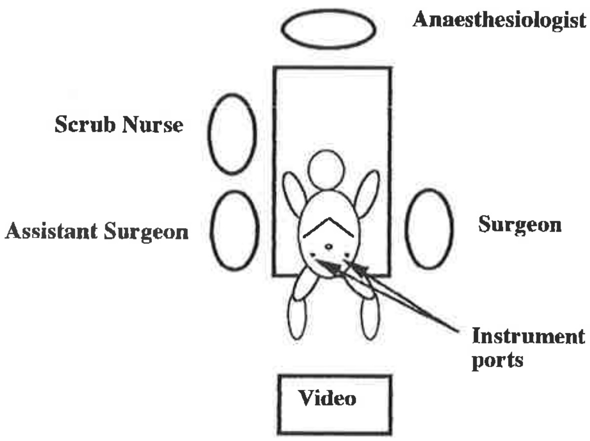

Fig. 1. Scheme of operating theatre layout

The patient was positioned at the foot of the table in the Lloyd Davies position and a silastic urethral catheter introduced to empty the bladder (Figs. 1 and 2). She was tilted head down to allow the viscera to be retracted away from the pelvis. Nitrous oxide was not used in the anaesthesia to minimise gaseous distension of the bowel. A mini-laparotomy was performed by making a 5-mm infra-umbilical incision, picking up the linea alba and incising it and the peritoneum to gain access to the abdominal cavity.

A purpose-built paediatric 4-mm telescope port was introduced directly into the abdomen and a CO_2 pneumoperitoneum established. Gas leak was minimised by transfixing the 4-mm port with a 3/0 purse-string suture. Two further ports were established, one in each iliac fossa, under direct internal video endoscopic control to prevent damage to the inferior epigastric vessels (which are prominent in this position) and the underlying viscera. Atraumatic graspers were introduced into each of these ports and a very thorough pelvioscopy performed. The graspers were used to manipulate the uterus, adnexae, and all the intrapelvic viscera to allow better inspection. The endoscopic view obtainable was unsurpassed, even better than that obtainable at open surgery.

Correspondence to: H. L. Tan

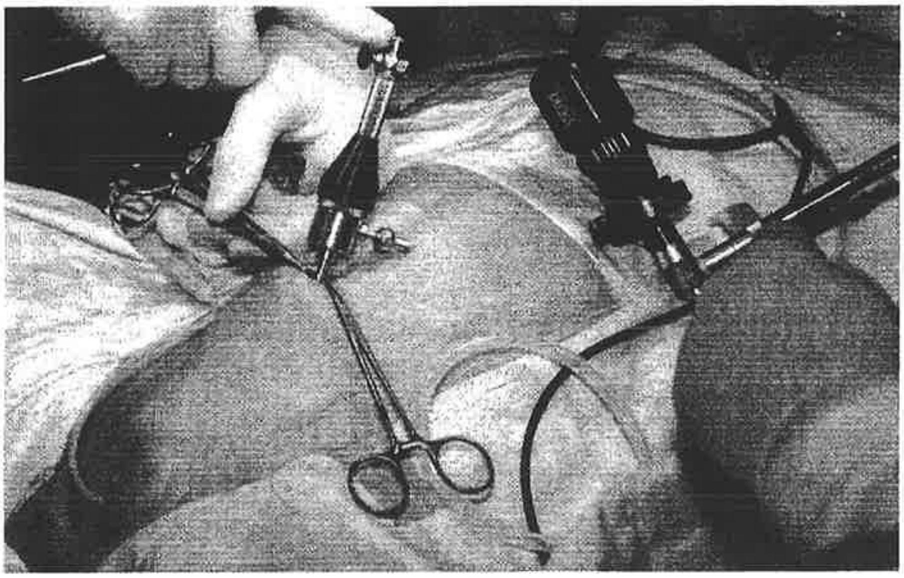

Fig. 2. Patient 1 positioned with telescope port inserted in infra-umbilical position

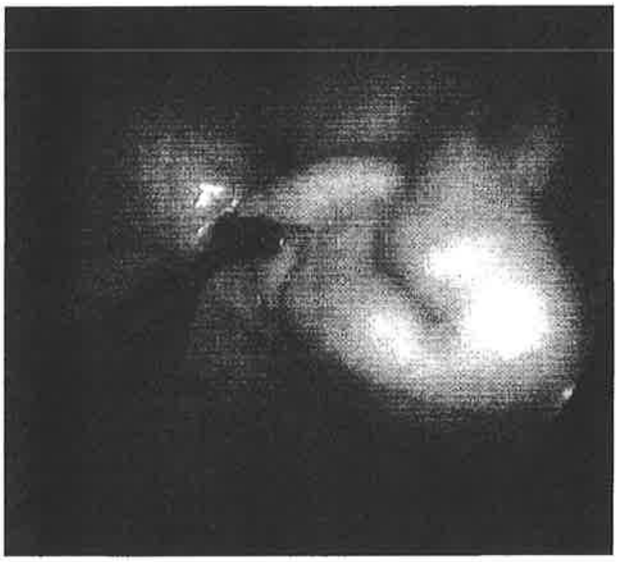

Fig. 3. Left ovary being pegged to lateral abdominal wall

No macroscopic extravesical tumour was identified, but a small, brownish lymph node was seen overlying the common lliac vein. The lymph node was removed laparoscopically for histology, and both ovaries were then identified in the pelvis and delivered into the abdomen proper. Each ovary was grasped by the atraumatic forceps in the left iliac fossa instrument port and a 3-mm needle holder was introduced into the right lower quadrant instrument port. A 0 chromic catgut endoloop was introduced into the same port and the ovaries were sutured to the lateral abdominal wall 2 cm above the pelvic brim using an extracorporeal knot-tying technique (Fig. 3).

Ten hollow 16-gauge stainless steel guide needles were implanted transperineally and their positions were verified laparoscopically. The legs were immobilised in a hip spica to prevent dislodgement. A morphine infusion was used for sedation during the period that the needles were in situ. Two courses of radiotherapy were administered. The postoperative course was uneventful.

Case 2. A 2-year-old child (11.45 kg) with a yolk sac tumour of the vagina was initially treated with chemotherapy alone. Persistently raised alpha-fetoprotein levels suggested persistent tumour. An examination under anaesthesia demonstrated a 1-cm nodule in the left fornix of the upper vagina. Of the two options offered, i.e., radical surgery versus localised radiotherapy, the parents decided to accept localised radiotherapy with ovariopexy.

The technique and position adopted were similar to those of the first patient. A thorough pelvioscopy failed to find evidence of tumour spread. The ovaries were fixed laparoscopically in a similar way to case 1. It was decided to attach metallic clips to each ovary to assist in dose calculation. Unfortunately, the only clip applicator currently available requires a 10-mm cannula. To introduce the 10-mm cannula, the umbilical telescope port was removed and the umbilical incision extended to allow its insertion.

Following successful ovariopexy, the hollow radiation needles were again inserted under direct laparoscopic control. The child's legs were immobilised in a hip spica as previously. This patient also had an uneventful recovery from the procedure, and the use of a larger instrument port in the umbilicus had no adverse physical or cosmetic effect.

Discussion

In recent years, the emphasis in the management of paediatric malignancies has shifted away from radical extirpative surgery to a more conservative approach using a combination of chemotherapy and limited surgery. We have also seen the introduction of localised curietherapy as definitive local therapy.

A significant morbidity of pelvic irradiation in females is ovarian dysfunction. Ovaries left in the radiation field suffer severe insult, resulting in complete ablation. Techniques of ovarian displacement and shielding can decrease gonadal irradiation by 80%–90%. Stillman et al., in a study of 182 long-term survivors of childhood cancers, found ovarian failure in 68% of children with ovaries within the radiation field. Those with ovaries at the edge of the field had significantly less ovarian dysfunction (14%), and those ovaries that were out of the treatment field did not have evidence of dysfunction [6].

Interstitial and intracavity curietherapy significantly reduces the dose to normal tissues, which is particularly important in paediatric patients. However, because of the proximity of the ovary to the target volume and the relatively low dose (10–20 gy) required for ovarian ablation, ovariopexy is required in most cases to conserve ovarian function. Flamant et al. reported normal masses and ovarian function in 10 to 11 patients with adequate follow-up following curietherapy for vulvovaginal rhabdomyosarcoma. To date, 2 healthy patients have delivered three healthy children [2]. Clearly, then, ovariopexy is an important procedure to consider in children undergoing pelvic irradiation, and laparotomy has until now been the only effective means of performing ovariopexy.

Laparotomy in children with malignancies is not without morbidity. Apart from the iatrogenic trauma of a large surgical scar, there is a significant risk of wound dehiscence, infection, and ventral hernias following laparotomy in children undergoing chemotherapy for malignancies. Laparoscopic ovariopexy eliminates such risks and brings with it the attendant advantages of "minimally invasive surgery", namely, much quicker convalescence and much less pain. Additionally, we believe that the view obtained at pelvioscopy using the current state-of-the-art video equipment is unsurpassed, as the image is magnified four times. This has the added advantage of increasing the accuracy of radiation needle placement in and around the tumour in patients undergoing local radiotherapy with interstitial curietherapy.

Piouvost et al. have reported successful laparoscopic ovarian fixation in adults, but no cases of laparoscopic ovarian fixation in children have been reported previously [5]. This may be due to a lack of suitable instrumentation, as the instruments currently in use for adult laparoscopic surgery are unsuitable for use in small children. The senior author has developed a range of laparoscopic instruments that can now be used safely in young infants and children and has reported successful pyloromyotomy using this set.

Our experience with these two patients leads us to believe that operative laparoscopy will have a significant role in the management of childhood malignancy, not only as a therapeutic tool for procedures such as ovariopexy and tissue sampling, but also as a useful diagnostic modality.

References

1. Donaldson S, Kaplan H (1992) Complications of treatment of Hodgkin's disease in children. Cancer Treat Rep 66: 977–989
2. Flamant F, Gerbaulet A, Nihoul-Fekete C, et al (1990) Long-term sequelae of conservative treatment by surgery, brachytherapy, and chemotherapy for vulval and vaginal rhabdomysarcoma in children. J Clin Oncol 8: 1847–1853
3. Hay SD, Shimada H, Raney R, et al (1985) Sarcomas of the vagina and uterus: the intergroup rhabdomyosarcoma study. J Pediatr Surg 36: 718–724
4. Loughlink, Retik A, Weinstein H, et al (1989) Genitourinary rhabdomyosarcoma in children. Cancer 63: 1600–1606
5. Piouvost M, Canis M, LeBovedec G, et al (1991) Transposition ovarienne percoelioscopique avant curietherapie dans les cancers du col uterin stade 1A et 1B. J Gynecol Obstet Biol Reprod (Paris) 30: 361–365
6. Stillman R, Schinfeld J, Schiff I, et al (1981) Ovarian failure in long term survivors of childhood malignancy. Am J Obstet Gynecol 139: 62–66

Pediatr Surg Int (1994) 9: 561–563

ORIGINAL ARTICLE

Initial experience with laparoscopic adhesiolysis in children

H. L. Tan, A. Mammen, and J. M. Hutson

Department of General Surgery, Royal Children's Hospital, Flemington Road, Parkville 3052, Vic, Australia

Accepted 1 December 1993

Abstract. Intra-abdominal adhesions are a well-known complication of laparotomy. We report our initial experience of ten children undergoing laparoscopy for the diagnosis and treatment of intra-abdominal adhesions. Significant adhesions were found in seven patients and successfully treated laparoscopically. Two patients required a second procedure, the first for recurrent adhesions 6 months following laparoscopic adhesiolysis, and the second because of an initial unsuccessful attempt. Even very extensive adhesions can be treated effectively and safely with very low morbidity. There were no conversions to open laparotomy. It has been our observation that pain localised to a healed laparotomy incision may be caused by adhesions to the undersurface of the scar, and lysis of these adhesions resulted in resolution of the pain in our patients.

Key words: Pediatric laparoscopic surgery – Laparoscopic adhesiolysis

Introduction

Intra-abdominal adhesions are a known complication of previous open surgery [3]. Except for patients presenting with frank evidence of bowel obstruction, it can be difficult to determine if recurrent abdominal pains are caused by post-operative intra-abdominal adhesions. Routine investigations are often of limited value, and laparotomy is rarely indicated unless there is corroborative evidence of small-bowel obstruction.

We have been exploring the role of laparoscopy in the diagnosis and management of post-operative intra-abdominal adhesions, and present our findings. Although previous surgery has been reported to be a contra-indication to laparoscopy [4], we have found that, with attention to detail, it can be performed safely. We report the use of laparoscopy for the diagnosis and treatment of suspected intra-abdominal adhesions in ten children and discuss the technical aspects and results of the procedure. Our results indicate that laparoscopy may be the investigation of choice in patients with suspected intra-abdominal adhesions.

Correspondence to: H. L. Tan

Materials and methods

During the period June 1992 to June 1993, ten patients underwent laparoscopy for suspected adhesions. Their presenting symptoms were post-operative recurrent incomplete small-bowel obstruction or severe recurrent abdominal pain following conventional laparotomy. All patients were investigated prior to laparoscopy with plain radiographs of the abdomen. An abdominal ultrasound (US) examination and barium meal follow-through were also performed in children presenting with abdominal pain only and in those who did not have radiological or clinical evidence of small-bowel obstruction. None of these investigations were of predictive value except for the exclusion of constipation and other non-related pathology, such as ovarian pathology. Patients underwent laparoscopy if they had evidence of dilated fluid-filled loops of small bowel on plain radiograph or they had pain sufficient to interrupt their life-style.

Open laparoscopy using the Hasson [2] technique is used in all laparoscopic procedures in our institution, even in patients without previous abdominal surgery. Blind punctures in children are especially hazardous, and are contra-indicated in patient with previous open surgery. All secondary cannulae are inserted under vision, well away from any abdominal-wall adhesions, to minimise the risk of iatrogenic visceral injury. Placing accessory cannulae well away from anterior abdominal-wall adhesions also facilitates the manipulation of instruments.

Adhesiolysis is performed in three steps. It is important initially to detach all adhesions between the abdominal wall and the underlying omentum or bowel (Fig. 1). Adherent bowel loops are detached with sharp scissor dissection to avoid inadvertent perforation. Particular care is taken with loops of bowel attached to the internal scar to ensure that there are no associated Richter herniae. Loose fibrinous adhesions are detached using a monopolar diathermy hook.

The next step in adhesiolysis is the freeing of omentum from the underlying bowel, to gain adequate access to the underlying small bowel (Fig. 2). The omental adhesions are best detached as close as possible to their serosal attachment, as this is virtually a bloodless plane. Care is

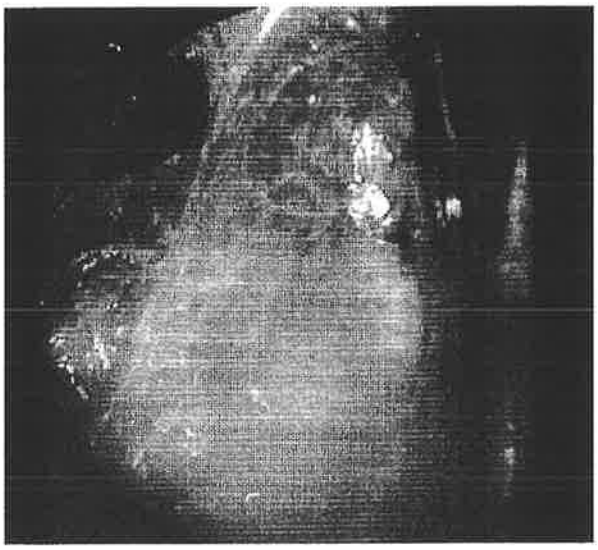

Fig. 1. Endoscopic appearance of extensive adhesions to anterior abdominal wall

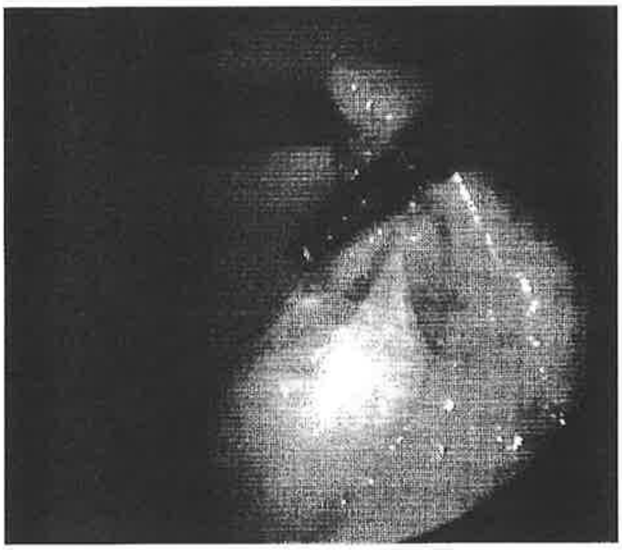

Fig. 2. Adhesions between omentum and underlying bowel

taken to ensure that appendices epiploicae are not mistaken for omentum, as bleeding can ensue from epiploic vessels, which may be difficult to identify as they retract into the surrounding fat when divided.

The bowel can only be adequately inspected after freeing omental adhesions. As in conventional open adhesiolysis, we start the inspection of the small bowel at the ileo-caecal junction and "walk" proximally to the duodenojejunal flexure. The loops of bowel can usually be inspected with ease by passing each loop from one pair of forceps to another in a two-handed fashion (Fig. 3). "Bread and butter" adhesions can usually be separated by gentle traction, but more fibrous adhesions require sharp dissection with micro-endoshears. It may be necessary to tilt the patient to facilitate inspection of the bowel, and it is often necessary to tilt patients into steep positions to allow bowel loops to fall away from the surgical field. Laparoscopic adhesiolysis can be tedious, but with attention to detail it has been our experience that even extensive adhesions can be successfully lysed.

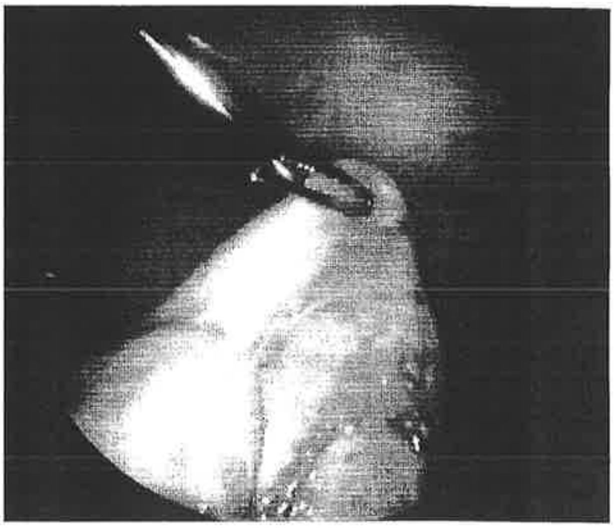

Fig. 3. "Bread and butter" adhesions viewed endoscopically

Results

During the period June 1992 to June 1993, a total of ten patients underwent laparoscopy for adhesiolysis for suspected intra-abdominal adhesions. Six were following appendicectomy and one each after urinary undiversion, major omphalocele repair, Duhamel's pull-through, and laparotomy for malrotation. Significant adhesions were found in seven patients involving the abdominal wall, omentum, and bowel loops. Four had omentum adherent to the internal abdominal wall scar and caecum. Three had extensive adhesions involving the abdominal wall, omentum, and bowel. All adhesions were completely lysed in these children.

Laparoscopy was initially unsuccessful in one patient due to complete obliteration of the abdominal cavity. This patient had had multiple open operations following delayed closure of an exomphalos major, and presented with recurrent incomplete small-bowel obstruction. US was subsequently performed on this patient, demonstrating free movement of underlying bowel in the right lower quadrant of the abdomen. He has subsequently undergone a second laparoscopy, and on this occasion a 1-cm open laparoscopy incision was made in the right lower quadrant and very extensive adhesions were identified and completely freed using a total of four ports. The patient is now completely asymptomatic.

No adhesions were found at laparoscopy in three patients presenting with severe colicky abdominal pain suggestive of adhesions. One patient had a recurrence of abdominal pain 6 months following laparoscopic adhesiolysis for very extensive adhesions. At repeat laparoscopy, the omentum was again adherent to the caecum and further adhesions had developed between several loops of terminal ileum. These new adhesions were lysed and she has been well since.

The mean operating time was 60 min (range 40–240 min). Blood loss was minimal and no bowel perforation occurred. One patient developed sepsis at a trocar site, which resolved with antibiotic therapy. The only complication was non-bilious post-operative vomiting in seven patients. There was no conversion to open laparotomy in any case. Unlike conventional adhesiolysis, naso-gastric drainage was not used in any patient, and patients did not develop post-operative ileus. The average post-operative stay was 2.2 days. The patients have been followed for up to 1 year and remain well and pain-free.

Discussion

Laparoscopic adhesiolysis has only been described in adult patients [1]. To our knowledge, this is the first report of laparoscopic adhesiolysis in children. This initial report demonstrates that adhesions can be treated effectively, safely, and with minimal morbidity laparoscopically.

The incidence of recurrence of adhesions following laparoscopic adhesiolysis is not known, but as there is less handling during laparoscopic adhesiolysis, it is possible that there would be a decreased propensity to recurrence. We have found laparoscopy especially useful in children with post-operative recurrent abdominal pain without clinical or radiological evidence of small-bowel obstruction. When one suspects, but cannot prove, the presence of adhesions, there is a natural reluctance to perform a conventional laparotomy. Laparoscopy is a much more readily acceptable option and provides the ideal diagnostic modality.

In seven (70%) of our patients adhesions were found to be responsible for the recurrent abdominal pain, and in the rest (30%) we were able to exclude adhesions as the cause with certainty. All these patients have subsequently been diagnosed as having other non-related pathology. It has been our observation that pain localised to the healed laparotomy incision may be caused by adhesions to the undersurface of the scar, as lysis of these adhesions resulted in complete resolution of the localised pain in our patients.

References

1. Adams S, Wilson T, Brown AR (1993) Laparoscopic management of acute small bowel obstruction. Aust N Z J Surg 63: 39–41
2. Hasson HM (1971) Modified instrument and method for laparoscopy. Am J Obstet Gynecol 110: 886–887
3. McEntee G, Pender D, Mulvin D (1987) Current spectrum of intestinal obstruction. Br J Surg 74: 976
4. Nottle PD (1992) Percutaneous laparoscopic cholecystectomy: indications, contraindications and complications. Aust N Z J Surg 62: 181–187

Aust. N.Z. J. Surg. (1994) **64**, 726–728

THORACOSCOPIC BIOPSY OF A PATHOLOGICAL VERTEBRAL BODY

H. L. TAN,* P. J. MCMURRICK,*† T. E. MERRIMAN* AND I. P. TORODE‡

Department of Surgery, The Royal Children's Hospital, Parkville, †Monash University Department of Surgery, Alfred Hospital, Prahran and ‡Department of Orthopaedic Surgery, The Royal Children's Hospital, Parkville, Victoria, Australia

When computed tomography (CT) guided biopsy of a pathological vertebral body fails, the accepted alternative has been open thoracotomy and biopsy. The authors wish to report the use of a thoracoscopic approach to biopsy of a pathological thoracic vertebra in a child, after an unsuccessful attempt at CT guided percutaneous biopsy.

Key words: biopsy, thoracoscopy, vertebra.

INTRODUCTION

The morbidity associated with open thoracotomy has led to the increasing acceptance of video-assisted thoracoscopy as an attractive alternative to open thoracotomy. It has been clearly demonstrated that thoracoscopy is associated with a lower morbidity and considerably less functional disability.[1,2]

While many reports have appeared recently of successful pulmonary, mediastinal and oesophageal surgery, there have been few reports of the thoracoscopic approach to the spine except for the simple drainage of an abscess.[3] The authors wish to report the successful thoracoscopic biopsy of a pathological thoracic vertebral body in a young child presenting with a destructive lesion in the vertebral body of T7.

CASE REPORT

An 18 month old male Vietnamese infant presented with a 3 week history of back pain and gait abnormality following a fall on to his back. The child had progressive difficulty with weight bearing and became increasingly anorexic in the weeks following the trauma.

At presentation, there was no tenderness over the thoracic spine, and no swelling was noted. However, he walked with a kyphosis to the left and had a low grade fever (37.4°C).

Plain X-rays demonstrated reduced disc space at T7/8 with associated irregularity of adjacent end plates and early bony destruction of the anterior part of the body of T7. The appearances were consistent with discitis, but osteomyelitis and tuberculosis in particular were entertained as possible differential diagnoses (Figs 1, 2).

A bone scan demonstrated localized uptake of technetium in the region of T7 corresponding to a soft tissue mass in front of the vertebral body of T7 seen on computed tomography (CT) scan. These findings were consistent with osteomyelitis, but a Mantoux test was non-reactive.

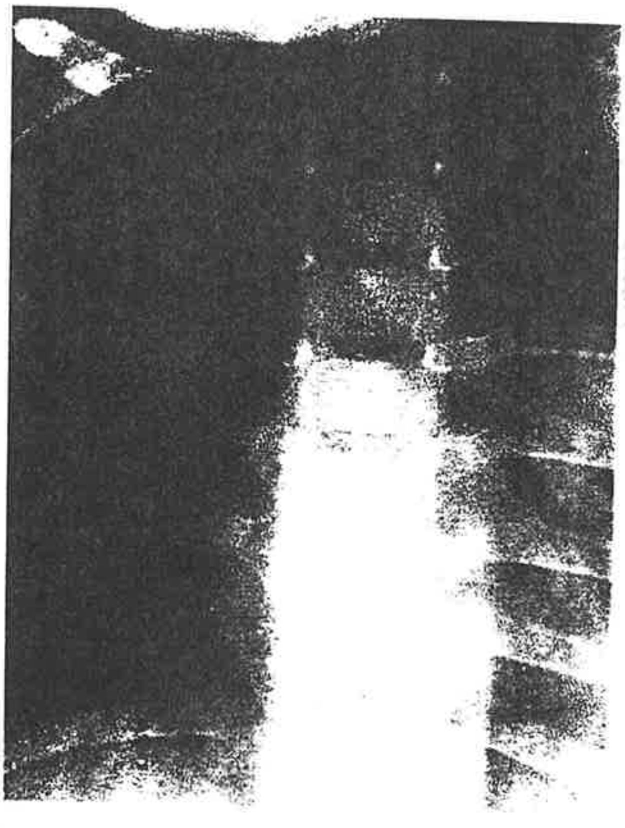

Fig. 1. PA X-ray demonstrating reduced disc space at T7–8 with early bone destruction, consistent with discitis or osteomyelitis.

Attempts at percutaneous needle biopsy of this lesion under CT guidance were unsuccessful. As an alternative to open thoracotomy and biopsy, a thoracoscopic approach was proposed and the technique was successfully

Correspondence: H. L. Tan, Chief of Endosurgical Services, The Royal Children's Hospital, Flemington Road, Parkville, Vic. 3052, Australia.

Accepted for publication 3 November 1993.

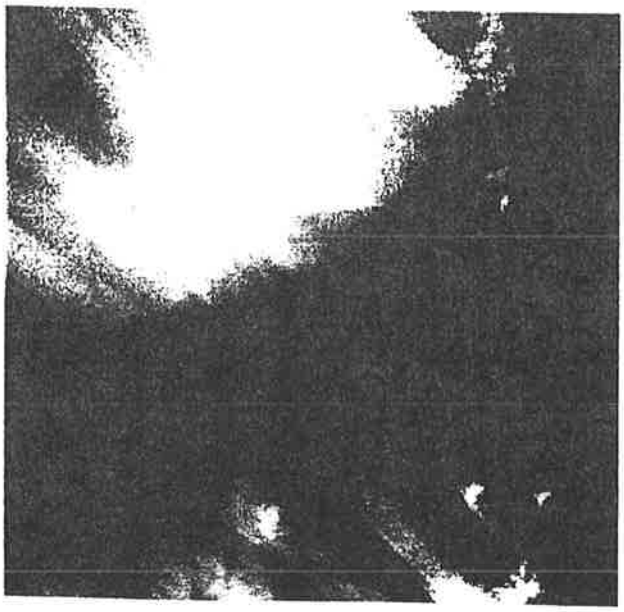

Fig. 2. Lateral X-ray demonstrating the same changes.

trialled in a single infant domestic pig as a prelude to attempting the procedure on this patient.

The patient was anaesthetised, paralysed and ventilated with a single lumen endotracheal tube and placed in a left lateral, semi-prone position. A right thoracoscopy was performed after deflating the lung by insufflation of CO_2 at 4 mmHg pressure through a blunt 5 mm trocar introduced in the 5th intercostal space at the anterior axillary line. The affected vertebral body was readily identified, with anterior swelling and deformity. Three more cannulae were inserted, one for lung retraction, and the others to perform the thoracoscopic manipulation.

The pleura overlying the vertebra was incised and overlying vessels diathermied. The sympathetic chain was identified and swept laterally providing excellent exposure to the anterior surface of the vertebral bodies. The invertebral discs above and below the lesion were clearly identified. A 4 mm diameter paediatric laparoscopic biopsy forceps was then introduced and several biopsies were taken from the appropriate vertebral body. A titanium clip was then attached to the vertebral body, which confirmed that the appropriate site was biopsied (Figs 3, 4). The lung was re-inflated, and the wound closed with steri-strips and a Tegaderm dressing. No intercostal drain was used.

The patient made a completely uncomplicated recovery and was discharged 24 h after surgery to await histology.

Adequate histology samples were obtained, and these showed acute non-specific inflammatory changes consistent with discitis. The patient was managed with oral antibiotics and has made an uneventful recovery.

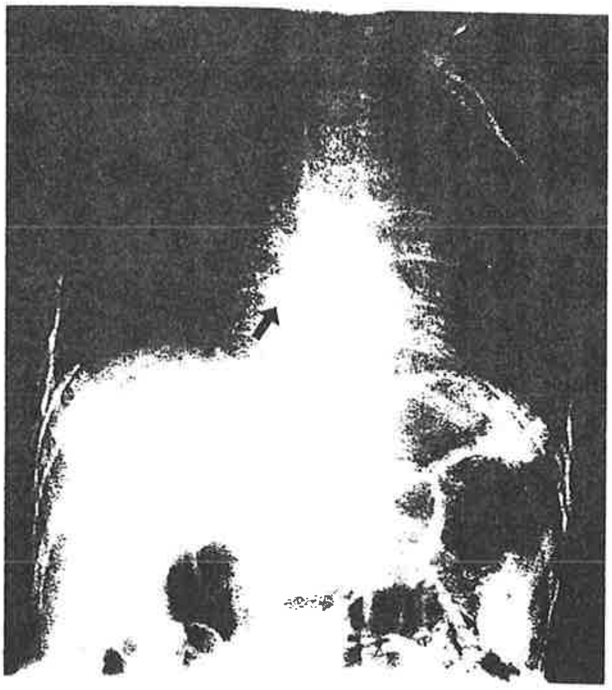

Fig. 3. PA film taken after the thoracoscopic biopsy with a metallic clip left *in situ* at the level from which the biopsy was taken, to confirm that the specimen had been obtained from the correct level (see arrow).

Fig. 4. Lateral view of the clip confirming the site of biopsy (see arrow).

DISCUSSION

Although successful thoracoscopic procedures are increasingly being reported, to the present authors' knowledge, thoracic vertebral biopsy has not been previously described. Mack *et al.* described the drainage of an intervertebral thoracic spinal abscess.[3]

The ease with which the vertebral body and the pathology can be approached thoracoscopically leads to the belief that a thoracoscopic approach to the anterior spinal column should be considered when CT guided percutaneous needle biopsies fail to yield results.

REFERENCES

1. Merriman TE. Corbat JD. Thoracoscopy: A useful diagnostic and therapeutic procedure. *Aust. N.Z. J. Surg.* 1993; **63**: 454–8.
2. Wakabayashi A. Expanded applications of diagnostic and therapeutic thoracoscopy. *J. Thor. Cardiovasc. Surg.* 1991; **102**: 721–3.
3. Mack MJ. Aronoff RJ. Acuff TE. Douthit MB. Bowman RT. Ryan WH. Present role of thoracoscopy in the diagnosis and treatment of diseases of the chest. *Ann. Thorac. Surg.* 1992; **54**: 403–9.

Aust. N.Z. J. Surg. (1994) **64**, 728–730

Minimally Invasive Therapy 1994: 3: 207–210

Case report: laparoscopically-assisted cysto-prostatectomy

H.L. TAN FRACS & J.M. HUTSON MD, FRACS
Department of General Surgery, The Royal Children's Hosptial, Melbourne, Australia

Summary. A 4-year-old child presented with recurrence of an embryonal rhabdomyosarcoma following previous limited excision, chemotherapy and pelvic irradiation. A decision was made to excise the bladder and prostate and a preliminary staging laparoscopy was performed to exclude extra-vesical metastases. It was evident that excellent access to retropubic structures could be obtained endoscopically, so informed consent was obtained for a laparoscopic cysto-prostatectomy. The bladder, bladder neck and urethra were entirely mobilized laparoscopically. Total laparoscopic time was 90 min and blood loss 150 ml. The need to create a permanent urinary diversion allowed us to make a 5 cm Pfannensteil incision to deliver the bladder and fashion an ileal conduit through this small incision. The patient made an uneventful recovery and was discharged after 6 days. Combining laparoscopy with conventional open surgery allowed us to gain access to a difficult anatomical site. Given the right indications, laparoscopic assistance can reduce considerably the iatrogenic trauma of open surgery and can facilitate the surgical exposure to structures normally inaccessible by a conventional extensile surgical approach.

Keywords: laparoscopy, prostate, rhabdomyosarcoma, cysto-prostatectomy

Introduction

The bladder is an intra-abdominal organ in infants and easily accessible by conventional surgery. However, surgical access to the prostate and urethra is more difficult, as these structures are deep to the arch of the symphysis pubis. It is sometimes necessary to perform a symphysiotomy to gain surgical access to the urethra, especially if the pelvis has been irradiated previously. We report our experience with the laparoscopic approach to the bladder, and describe a laparoscopically-assisted cysto-prostatectomy for recurrent rhabdomyosarcoma in a small child. The bladder and anterior urethra were mobilized entirely by laparoscopic methods, and were delivered through a 5 cm Pfannensteil incision. An ileal conduit was fashioned at the same time.

Correspondence: Mr H.L. Tan, Department of Surgery, The Royal Children's Hospital, Flemington Road, Parkville, Victoria 3052, Australia.

Case report

The patient, a boy aged 4 years and 8 months, presented with recurrent rhabdomyosarcoma of the bladder following local excision, chemotherapy and localized pelvic irradiation. There was no evidence of metastatic disease, and a staging laparoscopy with node biopsy showed no evidence of extra-vesical spread. A cystoscopy performed at the same time confirmed extension of the tumour from the trigone to the posterior urethra.

Cysto-prostatectomy with permanent urinary diversion was offered as the only treatment option possible, and informed consent was obtained to perform all or part of the excision laparoscopically, in an attempt to reduce surgial trauma to the child.

Operation details

The patient was placed in a Lloyd Davies position and a 8 F gauge silastic Foley balloon catheter inserted. The entire abdomen and perineum was prepared and draped, and peri-operative cephalosporin and metronidazole was administered. The patient was tilted into a steep Trendelenburg position, and a 4 mm reusable cannula was inserted through an infra-umbilical skin crease incision using the 'Hasson' technique [1].

The abdomen was insufflated to 12 mmHg pressure, and 5.5 mm instrument cannulae were inserted in each iliac fossa, taking care to avoid the inferior epigastric vessels. A further 11 mm instrument port was inserted in the midline between the symphysis pubis and umbilicus, to allow larger instruments to be inserted for haemostasis.

The bowel was retracted from the hollow of the pelvis into the abdomen. After ensuring that there was no evidence of extra-vesical tumour, it was decided to proceed with excisional surgery. The peritoneum over the dome of the bladder was incised under tension with monopolar hook diathermy, and the dome exposed (Figure 1). It was grasped with a pair of toothed spring-loaded graspers and counter traction applied between it and the anterior abdominal wall. This enabled the anterior bladder wall to be detached from the anterior abdominal wall with careful monopolar electrocoagulation. The medial umbilical ligaments were identified on either side of the bladder, detached from the umbilicus and excised *en bloc* with the bladder and the overlying peritoneum.

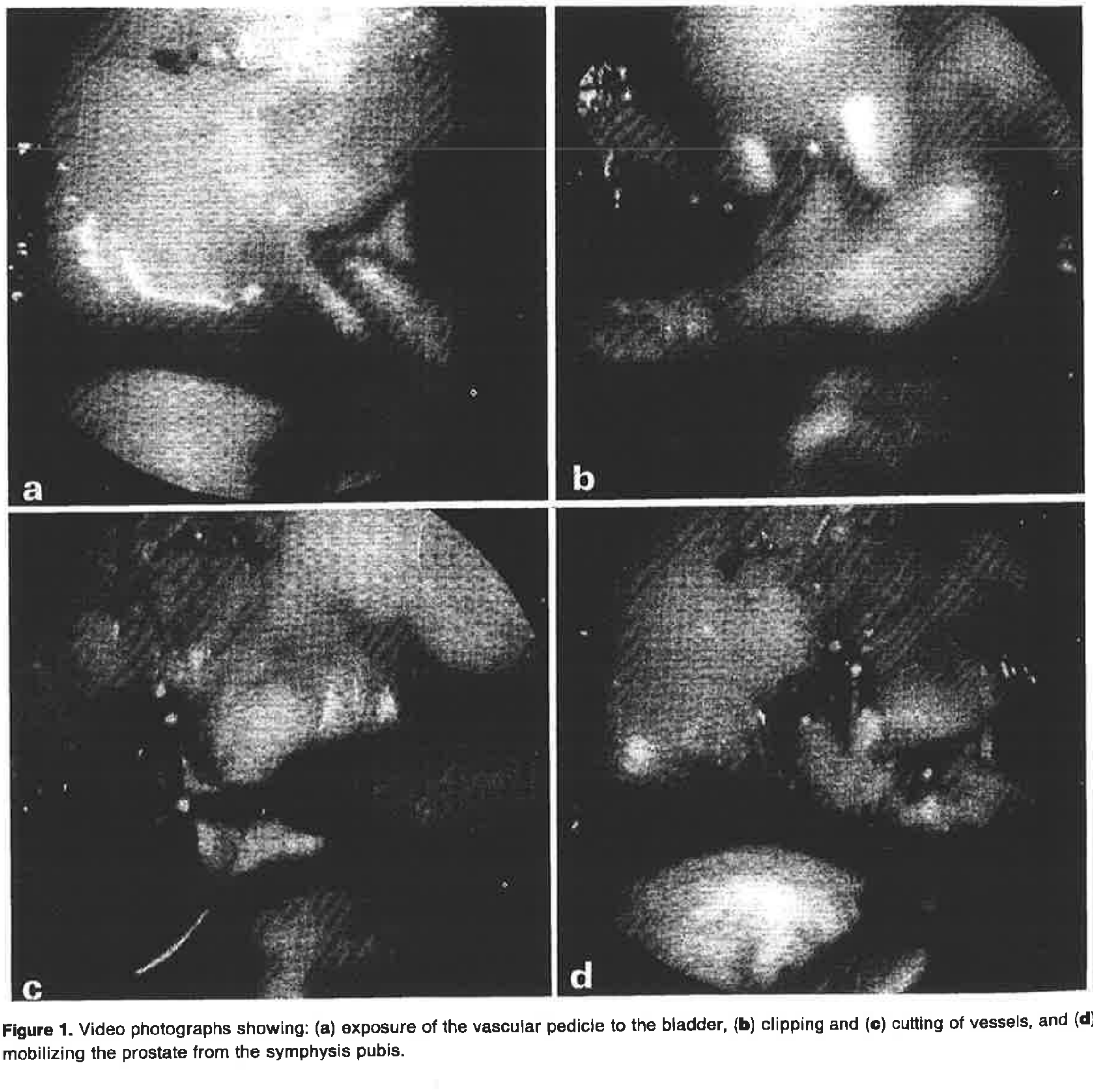

Figure 1. Video photographs showing: (**a**) exposure of the vascular pedicle to the bladder, (**b**) clipping and (**c**) cutting of vessels, and (**d**) mobilizing the prostate from the symphysis pubis.

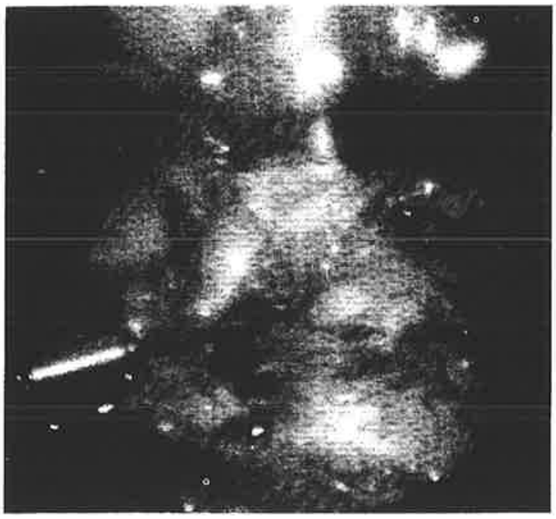

Figure 2. The entire bladder is detached, apart from a previous anterior abdominal scar.

The external iliac vessels on either side were exposed by detaching the medial umbilical ligaments and overlying peritoneum, and the plane between the bladder neck and the external iliac vein developed using the monopolar hook to divide the loose connective tissue. Careful dissection and separation of the bladder neck from the bony margins of the symphysis allowed identification of the vascular bundles on either side. Three 6 mm titanium clips were applied to each vascular bundle, and the vessels divided.

The posterior urethra was detached from its ligamentous attachment to the undersurface of the symphysis pubis by electrocoagulating the tissue prior to detaching it. After detaching the bladder and anterior urethra from the anterior abdominal wall and symphysis pubis (Figure 2), attention was focused on the recto-vesical pouch. The rectum was separated from the posterior bladder wall by monopolar hook diathermy, but dissection was hampered at this stage by accumulation of large amounts of irrigation fluid, obscuring the view and making it impossible to use the diathermy effectively. A Pfannensteil incision was then made to complete the posterior dissection, and to fashion an ileal conduit.

Total laparoscopic time was 90 min, and blood loss for the entire procedure was 150 ml. The patient made an uneventful recovery and was discharged on the sixth post-operative day. He remains well and tumour-free 16 months later.

Discussion

Major advances have occurred in laparoscopy in recent times, with reports of nephrectomy [2], colonic resection [3, 4] and other major procedures being performed entirely laparoscopically, and there is no doubt that laparoscopic surgery reduces iatrogenic trauma to the patient. A less commonly cited advantage of laparoscopic surgery is the ease of laparoscopic access to target organs traditionally difficult to reach by open surgical exposure, which allows the development of laparoscopically-assisted procedures. We obtained a clear, magnified view of the bladder neck allowing bloodless dissection and identification and clipping of the vascular pedicles to the prostatic urethra. The concept of combining laparoscopy with an open procedure to optimize surgical treatment is not new, as laparoscopically-assisted appendectomies [5] and colonic resections [6, 7] have been reported in adults, but we have not found any previous reports of its use in paediatrics.

We have demonstrated that laparoscopically-assisted mobilization of the bladder and posterior urethra greatly reduces the magnitude of an open procedure. In the present case it was necessary to convert to an open procedure because the accumulation of bloody fluid in the pelvis was obscuring vision. In addition, it was necessary to extract tissue without spillage and to fashion an ileal conduit, a procedure which is not yet being performed laparoscopically. As we discovered later, the fluid was difficult to drain because the steep Trendelenburg position was causing the fluid to accumulate in a large subphrenic reservoir constantly replenishing the fluid in the pelvis. With hindsight, we feel it would have been preferable to have commenced the dissection in the recto-vesical pouch and to have tilted the patient head up from time to time to empty the fluid reservoir.

Laparoscopically-assisted cysto-prostatectomy offers the benefits of a minimally invasive approach to a difficult resection, and has significantly reduced the morbidity in the patient. This case report illustrates the potential benefits of performing 'laparoscopically-assisted' procedures where laparoscopy is utilized to mobilize an inaccessible target organ before completing the procedure by conventional open surgery.

References

1 Hasson HM. Open laparoscopy versus closed laparoscopy: a comparison of complication rates: 1978. *Adv Planned Parenthood* **13**: 41–50

2 Clayman RV, Kavoussi LR, Soper NJ *et al.* Laparoscopic nephrectomy: initial case report. *J Urol* 1991; **146**: 278–82

3 Franklin ME, Pharand, Rosenthal D. Laparoscopic resection of left sigmoid colon lesion, low anterior resections, and APR. *2nd International Multispecialty Congress of Endosurgery*, Maui, Hawaii, 30 November–4 December 1992

4 Cooperman AM, Katz V, Zimmon D, Botero G. Laparoscopic colon resection: a case report, *J Laparoendosc Surg* 1991; **1**: 221–4

5 Wilson T. Laparoscopically assisted appendicectomies. *Med J Aust* 1986; **145**: 551

6 Schlinkert RT. Laparoscopic assisted right hemicolectomy. *Dis Colon Rectum* 1991; **34**: 1030–1

7 Polglase AL, Skinner SA, Johnson WR. Laparoscopic assisted right hemicolectomy with valtrac bar (biofragmentable anastomotic ring) ileotransverse anastomosis. *Aust NZJ Surg* 1993; **63**: 481–4

Annales Chirurgiae et Gynaecologiae 83: 143–147, 1994

THE ROLE OF LAPAROSCOPIC SURGERY IN CHILDREN

H. L. TAN

FROM THE DEPARTMENT OF ENDOSURGERY, THE ROYAL CHILDREN'S HOSPITAL, MELBOURNE, AUSTRALIA

ABSTRACT

Although laparoscopy was widely evaluated by Drs Stephen Gans and George Berci in the 1970's, it did not become a useful clinical modality in paediatric surgery until relatively recently. It was reported by these workers to be a useful diagnostic modality, but as a therapeutic tool, its role was limited to simple biopsies. The introduction of computed tomography (CT) scan abdominal ultrasound imaging also limited its clinical application, as these modalities allowed very accurate diagnosis of clinical pathology without resorting to laparoscopy for diagnosis.

Recently, the widespread acceptance of laparoscopic surgery in adult surgical practice has lead many centres including ours to evaluate the role of laparoscopic surgery in paediatrics. Although it will be some time before its benefits or otherwise in paediatrics are established, there is no doubt that laparoscopic surgery is safe in children in the hands of the skilled laparoscopist. There is also no doubt that the paediatric surgeon in future will have to be skilled in laparoscopic surgery as increasing demands are made on us to treat common surgical conditions without causing the patient physical harm. This paper reviews some of the common conditions being treated by the laparoscopic route in our institution and attempts to evaluate the early results.

KEY WORDS: LAPAROSCOPIC SURGERY; PAEDIATRIC LAPAROSCOPY

Advances in technology such as the charge coupled device (CCD) video camera, Xenon light source, and high resolution monitors have made complex procedures such as laparoscopic cholecystectomy possible. These developments for the first time allowed the surgeon to operate with both hands, with an assistant directing the video camera. Until its introduction, therapeutic intervention was restricted to simple procedures that can be performed with one hand, as it was necessary for the surgeon to hold the eye piece while operating.

Drs Stephen Gans and George Berci investigated and reported paediatric applications of laparoscopy in the early 1970's (2). Although they concluded that it was a useful diagnostic tool, it was not widely accepted in paediatrics as it was invasive and difficult to perform in infants. Many surgeons were uncomfortable about the use of the blind Veress needle puncture technique in children, with the potential risk of major visceral injury, and regarded these risks as unacceptable for a diagnostic procedure. Furthermore, the introduction of CT scan, diagnostic ultrasound and more recently magnetic resonance imaging (MRI) provided a highly accurate and totally noninvasive diagnostic tool which left little indication to perform diagnostic laparoscopy in children.

Adult laparoscopic instruments became available by 1990, but our early evaluation of this equipment lead us then to conclude that they were unsuitable for use in small children. The working ports were large (10 mm), too long and it did not make sense to make several 10 mm incisions for laparoscopic surgery when many paediatric procedures could be performed through incisions not much longer than 2 to 3 cm. The length of the instruments meant that they had to be held with both arms widely abducted when used in a small cavity and were ergonomically unsuited (5). Since then, paediatric instruments have become available and we have performed complex laparoscopic surgery in children ranging in age from an ex-premature three week-old infant (1.7 kg) to young adults. We report our overall experience and results.

CURRENT CLINICAL APPLICATIONS

LAPAROSCOPIC APPENDICECTOMIES

Appendicitis is the commonest paediatric surgical emergency that lends itself to laparoscopic surgery, and this has become the "gall bladder" of paediatric surgeons with many centres cutting their first laparoscopic teeth on children with appendicitis (3, 9).

We have been performing laparoscopic appendicectomies in our institution since 1990. Preliminary results indicate that laparoscopic appendicectomy is at least as safe as conventional open appendicectomy, and may offer the benefits of reduced hospitalisation and quicker recovery. These results are reflected in other paediatric appendicectomy series and are not unique to our institution.

LAPAROSCOPIC PYLOROMYOTOMY

Since our description of the technique of laparoscopic pyloromyotomy (5, 6), we have treated 37 patients with infantile hypertrophic pyloric stenosis entirely laparoscopically. There were no conversions to open laparotomy, and no mucosal perforations. It is safe, quick and effective in our hands. However, many surgeons argue that there is little to be gained by performing this laparoscopically, as they can perform the operation through a small incision. Unfortunately, small incisions in small infants grow to become large incisions in adults. Whether we like it or not, laparoscopic surgery has introduced another consideration which was irrelevant to the surgeon previously, and that is the cosmetic results from our surgical intervention. The fact that many centres now perform conventional pyloromyotomy through a circumumbilical route described by Tan and Bianchi (8) indicates that the cosmetic appearance is becoming an important factor. While the circumumbilical route offers minimal cosmetic deformity, it is often difficult to perform and requires considerable traction on the stomach and pylorus to deliver a large tumour. The scars may be minimal but it is *not* minimally invasive to the patient.

Laparoscopic pyloromyotomy on the other hand embraces the concept of minimally invasive surgery, as the operation is performed *in situ*, with very minimal handling and trauma to the abdominal wall and viscera. It eliminates the risk of would dehiscence which has been reported in most series of conventional pyloromyotomy (4). Furthermore, the time taken for laparoscopic pyloromyotomy is now the same or even shorter than that taken to perform a conventional open pyloromyotomy. It is technically an easy operation to perform laparoscopically, and has to be seen to appreciate its simplicity. Laparoscopic pyloromyotomy in our institution is at least as safe as conventional pyloromyotomy, and may offer some benefits. The role of laparoscopy in the management of infantile hypertrophic pyloric stenosis at this moment remains controversial. Whether it gains widespread acceptance in the future will depend on the results reported from several institutions currently performing this procedure laparoscopically.

Laparoscopy is useful in children with malignancies (7). A laparotomy is a major undertaking in patients undergoing chemotherapy or radiotherapy, with increased risks of poor wound healing. Laparoscopy offers a minimally invasive method of tissue sampling, ovariopexy and in the diagnosis of the acute abdomen. Unlike the experience of others, thrombocytopaenia and bleeding diathesis is *not* a contra-indication to endoscopic surgery, as we have performed laparoscopic procedures in thrombocytopaenic children on chemotherapy, with minimal morbidity. It is, after all, minimally invasive.

PAEDIATRIC LAPAROSCOPIC NEPHRECTOMY AND FUNDOPLICATION

Paediatric laparoscopic nephrectomy (1) (H.L. Tan, J.M. Hutson: Abstract: Pediatric Laparoscopic Nephrectomy. Presented at 1993 Annual meeting, Academy of Pediatrics, Washington, U.S.A., unpublished) and fundoplication (J.B. Atkinson, H. Applebaum, P.R. Theodore et al: Abstract: Laparoscopic Nissen fundoplication in the Pediatric Population. Presented at Pacific Assoc Ped Surg, Cairns, Australia, 1993, unpublished) have only been reported recently, and preliminary results indicate that laparoscopy offers benefits in the reduction of postoperative pain and morbidity. Laparoscopic nephrectomy, however, is performed via the transperitoneal route, and one must balance the risks of adhesion formation against the conventional retroperitoneal open approach. Retroperitoneal laparoscopic nephrectomy has recently been reported in adults. In our experience, however, the retroperitoneal laparoscopic route is difficult in children because of the limitations imposed on the working cannulae by the small amount of space between the 12th rib and the iliac crest. We have performed seven nephrectomies and one heminephrectomy in our institution via the intraperitoneal route without morbidity, and believe that it has substantial benefits in reduction of postoperative pain and minimal disfigurement.

ABDOMINAL PAIN

One of the commonest problems confronting a paediatric surgeon is the child with recurrent abdominal pain (RAP). While the majority of children with RAP do *not* have organic pathology, a significant number of children present with recurrent right iliac fossa pains and a strong family history of "grumbling appendix". Most surgeons do not report this condition and yet it is the experience of every paediatric surgeon that it is sometimes necessary to perform a "mini" laparotomy and elective appendicectomy, albeit reluctantly, in such patients. Diagnostic laparoscopy and appendicectomy is particularly useful in these children as it offers a complete exploration of the intraperitoneal structures in a way not possible by conventional "mini" laparotomy in these children.

MANAGEMENT OF ADHESIONS

Laparoscopy has been useful in the diagnosis and management of adhesions in patients with previous open surgery. The current indication for laparoscopic adhesiolysis are patients presenting with subacute small bowel obstruction, or patients with severe recurrent abdominal pains following open surgery. While adhesiolysis has been reported in acute small bowel obstruction, we have not yet treated a patient with complete small bowel obstruction laparoscopically, although we are prepared to do so. It has been our experience that extensive adhesions can be lysed successfully laparoscopically. Adhesiolysis is technically difficult and should not be attempted unless one has acquired sufficient laparoscopic skills to deal with potential complications.

Patients presenting with recurrent abdominal pains following open surgery can be a difficult clinical problem, as routine radiological investigations will not exclude adhesions with certainty, yet open laparotomy seems to be a major step to take to exclude adhesions in these children. It is useful in these patients.

TABLE 1

Time taken for first 20 cases of laparoscopic pyloromyotomy.

Case Number	Time taken (minutes)	Case Number	Time taken (minutes)
1	50	11	15
2	30	12	30
3	41	13	30
4	20	14	30
5	20	15	22
6	30	16	30
7	30	17	20
8	30	18	20
9	40	19	20
10	30	20	7

THORACOSCOPY

Schier and his co-workers have reported extensive experience with thoracoscopic surgery (F. Schier: Personal communication). There is no doubt that considerable reduction in morbidity can be achieved if a thoracotomy can be avoided, and there will be widespread clinical thoracoscopic applications in children. We have reported the thoracoscopic biopsy of diseased thoracic vertebrae, and believe that it will have a useful place in spinal surgery.

CONTROVERSIES

Many controversies still surround paediatric laparoscopic surgery. A common objection voiced is the length of the laparoscopic procedure. While there is no doubt that many laparoscopic procedures take longer to perform initially than open procedures, one must acknowledge that much of the time taken is related to the learning curve. This is amply demonstrated in our own analysis of the time taken to perform laparoscopic pyloromyotomy as shown in Table 1.

Similarly, the criticism that laparoscopic surgery is making a simple operation complex relates to an individual's skill. There is no doubt that laparoscopic surgery requires practice, but once the basic surgical skills of tissue manipulation, haemostasis and suturing are mastered, it is no more difficult than open surgery.

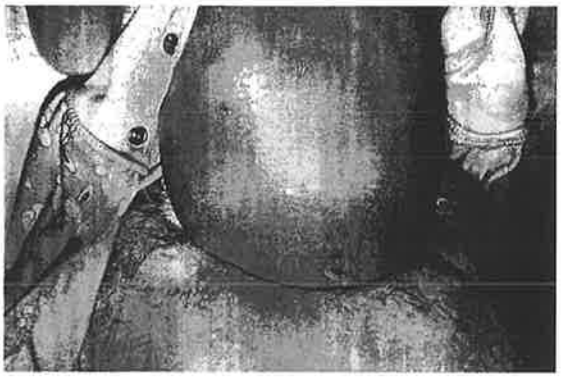

Fig. 1 A. Laparoscopic pyloromyotomy: cosmetic results one week after surgery.

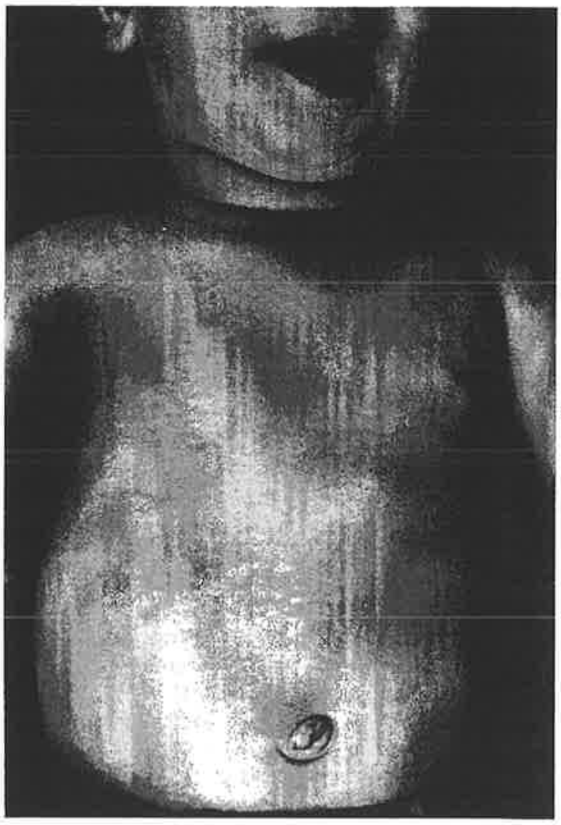

Fig. 1 B. Laparoscopic pyloromyotomy: results at six months.

There is also an impression that children recover very quickly from conventional open surgery, and that the benefits from laparoscopic procedures in the adult patients are not seen in children. While most surgeons will have anecdotal experience of children being discharged 24 hours following conventional appendicectomy, this is by no means the usual experience. In a surgical audit performed at one of our institutions, children undergoing laparoscopic appendicectomy were shown to have a shorter hospital stay of two days when compared to those undergoing conventional appendicectomy. However, our data require more critical evaluation, as the conventional appendicectomy group is weighed with children with large appendiceal abscesses who are currently considered unsuitable for laparoscopic appendicectomy. Notwithstanding this, however, it is our impression that children return to full normal activity much quicker after laparoscopic appendicectomy.

Likewise, another argument put forward is that the incisions made for conventional open surgery are small anyway, but this fails to take into account the fact that small incisions become large incisions with growth. The end result of laparoscopic pyloromyotomy however, is completely acceptable cosmetically (Figs 1 A, B).

In reality, laparoscopic surgery is probably more difficult to learn, and for a given procedure, more difficult to perform. However, there is no doubt that there is increasing patient and parental pressure to perform minimally invasive surgery. The scar may not be important to the surgeon, but it is of paramount importance to the recipient. If an operation can be performed laparoscopically with equal safety and effectiveness as a conventional procedure, then it should not be denied to our patients.

CONCLUSION

There is no doubt that laparoscopic surgery is here to stay. Initial reluctance has given way to cautious enthusiasm by paediatric surgeons. It will be some time before its final role in paediatrics will be determined, but with rapidly developing new technology, of telepresence, robotics and virtual reality, there is no doubt that in the future, most routine surgical procedures can be performed without causing harm to the patient.

REFERENCES

1. *Ehrlich RM, Gershman A, Mee S, Fuchs G:* Laparoscopic nephrectomy in a child: expanding horizons for laparoscopy in Pediatric Urology. J Endourol 6 (6): 463, 1992
2. *Gans SL, Berci G:* Advances in endoscopy of infants and children. J Pediatric Surg 6: 199, 1971
3. *Pier A, Gotz F, Bacher C, Ibald R:* Laparoscopic appendicectomy. World J Surg 17: 29, 1993
4. *Spicer RD:* Infantile hypertrophic pyloric stenosis: a review. Br J Surg 69: 128, 1982
5. *Tan HL:* Laparoscopic surgery in children and infants. In: Laparoscopic abdominal surgery. Eds J.N. Graber, L.S. Schultz, J.J. Pietrafitta and D.F. Hickok. McGraw Hill 1993.
6. *Tan HL, Najmaldin A:* Laparoscopic pyloromyotomy for infantile hypertrophic pyloric stenosis. Pediatr Surg Int 8: 376, 1993
7. *Tan HL, Scorpio RJ, Hutson JM et al:* Laparoscopic ovariopexy for paediatric pelvic malignancies. Pediatr Surg Int 8: 379, 1993
8. *Tan KC, Bianchi A:* Circumumbilical incision for pyloromyotomy. Br J Surg 73: 339, 1986
9. *Valla JS, Limone B, Valla V et al:* Laparoscopic appendectomy in children: Report of 465 cases. Surg, Lap & Endoscopy 166, 1991

Received: October 25, 1993

Address: H.L. Tan, M.D.
Endosurgery Unit
The Royal Children's Hospital
Flemington Road
Parkville, Melbourne, Victoria, 3052
Australia

Chapter from:

"Laparoscopic Abdominal Surgery"

Editors:

John N Graber, Leonard S. Schultz, Joseph J. Pietrafitta
& David F. Hickok

McGraw Hill 1993
ISBN 0-07-023989-4

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Laparoscopic Surgery in Children and Infants

Hock L. Tan

The possibility of performing surgery with minimal iatrogenic trauma has the same validity for children as it has for adult general surgery. However, until recently, most reports of successful pediatric laparoscopic surgery have been for older children, and laparoscopy for smaller infants and babies has been confined to diagnostic procedures. The reason for the delay is the lack of suitable instrumentation.

The author has been developing laparoscopic instrumentation for use in infants and older babies, which has extended the usefulness of laparoscopy in these patients.

Laparoscopic Equipment

The standard laparoscopic equipment for adult procedures is unsuitable for use in young children. The length of the adult telescope and the diameter of its cannula make it unwieldy for babies. For example, it makes no sense to make several 10-mm incisions for large cannulas when many pediatric procedures are performed through incisions that are often not much more than 2 to 3 cm long. The bevels of the larger trocars are also too long, and the tip reaches the posterior abdominal wall in small babies when the trocars are established and severely restricts access to any anterior structures. We have designed a telescope and a complete set of instruments for use through 4-mm cannulas that overcome these technical problems.

Current staplers and clip applicators, however, still require a large instrument port, and this limits our present capacity to use these devices in the very young. We are developing new staplers and clip applicators suitable for smaller ports, and this will eventually enhance our ability. In older children it is possible to introduce clips and staplers through the umbilical port with minimal iatrogenic and cosmetic trauma. In general, the adult laparoscopic set can be used effectively in older children (from around the age of 8 onward). However, when dealing with children younger than 8 years old, there are several essential differences in the laparoscopic technique that are related to differences in anatomy or size. These will be discussed.

Anatomic Considerations

The umbilicus is very busy in a neonate (Fig. 25-1). The two umbilical arteries (lateral umbilical ligaments) and the umbilical vein (ligamentum teres) are not obliterated for several weeks. Care must be taken to avoid opening these structures because there is a potential risk of gas embolism if a Verres needle is inadvertently inserted into these structures and CO_2 insufflated unknowingly.

The falciform ligament and the umbilical vein remnant (ligamentum teres) are very prominent structures in infants and children (Fig. 25-2). A Verres needle introduced into the upper abdomen will easily dissect between the two loosely attached folds of peritoneum forming the falciform ligament, and we can easily be misled into thinking that the Verres needle is in the abdomen and insufflate the falciform ligament instead.

The neonatal bladder is an intraabdominal organ, and the urachal remnant is attached to the umbilicus. It would be easy to puncture the urachus and perforate the bladder with a Verres needle. It is therefore mandatory to ensure that the bladder is completely empty immediately prior to surgery.

Unlike in the adult, in children the different layers of the abdomen are very loosely attached

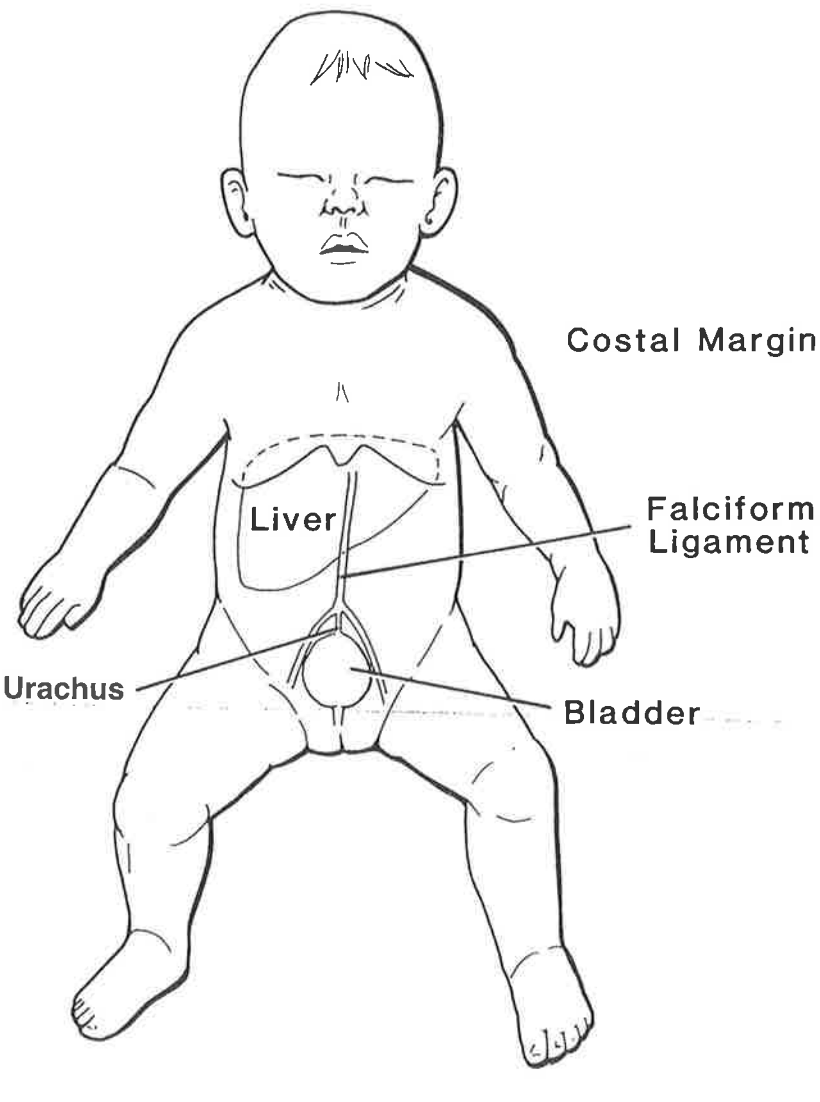


Figure 25-1
Anatomic relationships of the bladder, urachus, umbilical arteries, ligamentum teres, falciform ligament, and liver to the umbilicus in the neonate.

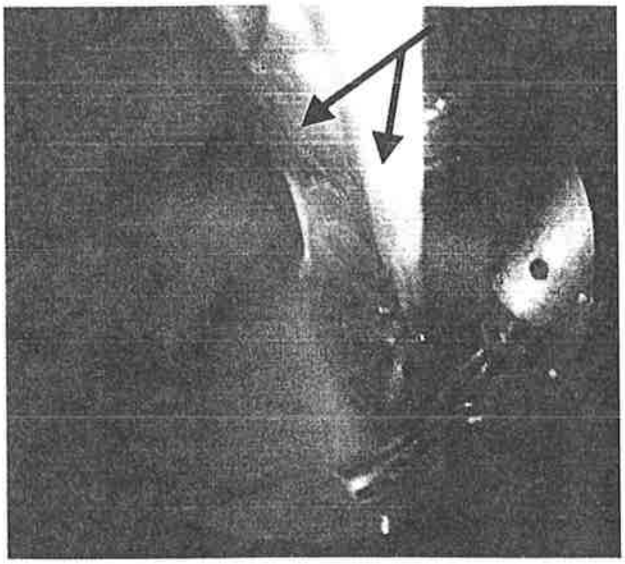


Figure 25-2
The prominent umbilical vein (ligamentum teres) and falciform ligament in the neonate (arrow).

to each other, and lifting the abdomen to establish a trocar simply allows the abdominal muscle to separate from the skin and subcutaneous tissues, making trocar placements more difficult. The peritoneum is also the toughest layer of the abdomen to puncture in an infant and is very loosely attached to the anterior abdominal wall, particularly in the region between the symphysis pubis and the umbilicus. The peritoneum has an inherent tendency to tent away from an advancing needle or trocar. Because of these properties, it can be very difficult to feel if a Verres needle has actually punctured the peritoneum in a child inasmuch as the peritoneum will dissect away from the abdominal wall with the advancing Verres needle (Fig. 25-3). The saline drop test is equally unreliable because of this laxity of peritoneal attachment.

Similarly, monitoring the insufflation pressure is not helpful in determining if gas is being insufflated into the correct cavity. The author has seen CO_2 dissecting all the way around into the posterior parietal peritoneum from an anterior puncture in his initial experience with laparoscopic surgery. The neonatal and infant liver overhangs the costal margin, and its lower margin reaches the umbilicus in neonates. There is a risk of injury to the liver if blind punctures are made in the upper abdomen in very young infants. Even under direct internal endoscopic control, the tip of the cannulas can be perilously close to the anterior surface of the liver (Fig. 25-4). The inferior vena cava and

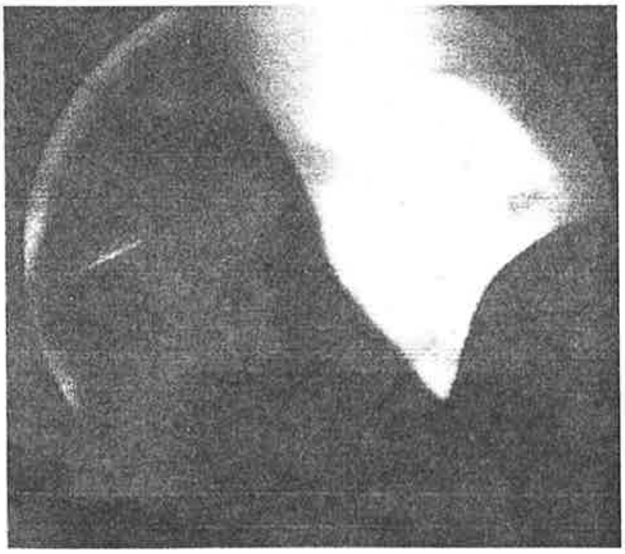


Figure 25-3
The peritoneum is a very sturdy tissue in the neonate, and it will tent away from the muscle and fascia when needles or trocars are inserted.

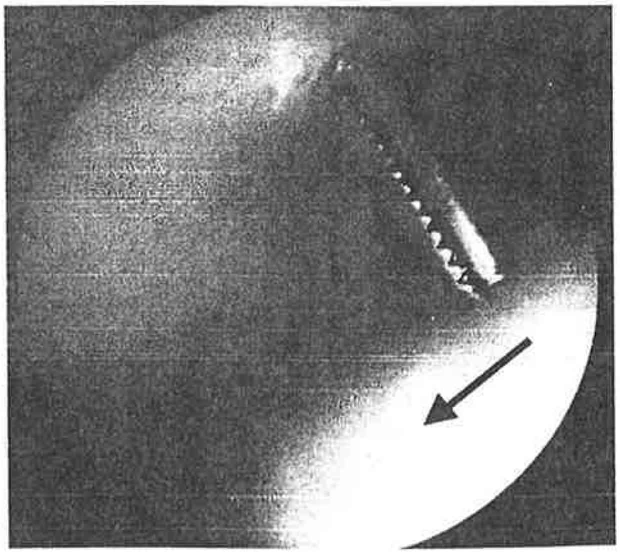


Figure 25-4
The anterior surface of the liver (arrow) is perilously close to the abdominal wall despite a pneumoperitoneum of 10-mmHg pressure.

aorta are barely 1 cm away from the anterior abdominal wall.

Because of the differences highlighted, we do not believe using a Verres needle to create the pneumoperitoneum is safe in small babies and infants.

Establishing the Pneumoperitoneum

To establish the pneumoperitoneum, we recommend the Hasson method. We make a small incision in the circular periumbilical skin crease. In small babies, a supraumbilical approach is easier because there is only one structure (the umbilical vein) to deal with, as opposed to the two umbilical arteries and urachus if one chooses an infraumbilical approach. This difference is much less apparent in older children.

The linea alba is identified, and a small transverse incision is made through the linea alba. We then identify either the umbilical vein (when using a supraumbilical approach) or the urachal remnant and lateral umbilical ligament (when using the infraumbilical approach) and pick up these structures with a hemostat. The peritoneum can then be easily opened on either side of one of these structures with a pair of iris scissors, and the instrument port introduced directly into the abdominal cavity, and insufflation begun. Use maximum pressures of 7 to 10 mmHg in neonates, 12 mmHg in older children.

A purse-string suture or vertical inverting mattress sutures should be placed on either side of the cannula to minimize gas leak and to help stabilize the 4-mm port. Miniature Hasson type cannulas are currently being developed that will reduce gas leaks.

Cannula Placement

Even at maximum insufflation, there is very little room in a baby to perform laparoscopic procedures such as intracorporeal knot tying, and the proximity of adjoining viscera makes the use of diathermy more hazardous. However, the baby's small size also means that the surgeon has very easy visual access to every abdominal viscera apart from the retroperitoneal structures.

Because the surgeon has to work in a small area, the instrument cannulas often have to be very close to each other, and we have to be careful that instrument clashes do not occur. In choosing trocar sites, it is better to establish the instrument ports further away from the operative field and not directly above the operative field because this allows more room for manipulation of the instruments. Having the instrument port too close to the area you wish to operate on will severely impede your ability to retract or manipulate viscera when required. In choosing trocar placement, always place the instrument trocars ahead of the endoscope to facilitate identification of "lost" instruments.

We have found the easiest and least traumatic way of establishing the instrument ports is to make a full thickness incision through the entire thickness of the anterior abdominal wall, including the peritoneum, with a no. 11 scalpel blade. The middle finger should rest on the blade as a guard to prevent the blade from penetrating too far into the abdominal wall and damaging the underlying viscera. The tip of the no. 11 scalpel blade should always be in full endoscopic view because the tip of the blade is close to the underlying abdominal viscera and can do damage by an injudicious stab. Once the peritoneum has been punctured by the no. 11 scalpel blade, the incision in the peritoneum should be enlarged to about 5-mm length to facilitate the next step.

A pair of straight mosquito hemostat forceps is inserted through the incision, the tip advanced through the peritoneal incision, and a tract created by spreading the hemostats. The instrument cannulas can then be inserted through the tract effortlessly, although it is still necessary to use a "screwing" action to advance the cannula through the layers of the anterior abdominal wall. The peritoneum in the suprapubic area is particularly difficult to penetrate in infants because of the loose attachment of the peritoneum to the undersurface of the abdominal wall (inasmuch as it has to accommodate the infantile bladder as it distends).

Most pediatric procedures can be performed using 4-mm or 5.5-mm cannulas, but it is sometimes necessary to use a larger (10-mm) port to extract viscera, such as appendixes or gallbladders, or if stapling is required. The best position for the placement of large trocars is through the linea alba via a small periumbilical incision. It is easy to extend this incision circumferentially to accommodate the 10-mm cannula with minimal cosmetic or iatrogenic trauma.

Pyloromyotomy (Ramstedt's Operation)

Pyloromyotomy is an operation that lends itself to laparoscopic surgery and requires only one 4-mm telescopic port and two 4-mm instrument ports. The patient is positioned at the foot of the operating table. The 4-mm telescope trocar is established in the manner already described earlier in this chapter. The surgeon initially stands on the patient's right while this first trocar is being established. The surgeon should then reposition himself or herself to sit at the end of the table, facing the patient's feet. The assistant surgeon should stand on the surgeon's right, and the scrub nurse on the surgeon's left. The anesthesiologist is at the front of the table on the surgeon's right. The operating table is tilted head up to allow the abdominal viscera to fall away from the operative field. The video monitor is positioned at the front of the operating table. This arrangement allows everyone involved in the operation to have an excellent view of the entire endoscopic proceeding on the one monitor (Fig. 25-5).

An insufflation pressure of 7 mmHg is adequate, although it can be increased to 10 mmHg if necessary. Two instrument ports are established in each upper quadrant of the abdomen under direct video-endoscopic control. Once again, special care has to be taken when inserting these ports because the liver is only about 1 cm away from the anterior abdominal wall. The ports should be placed midway be-

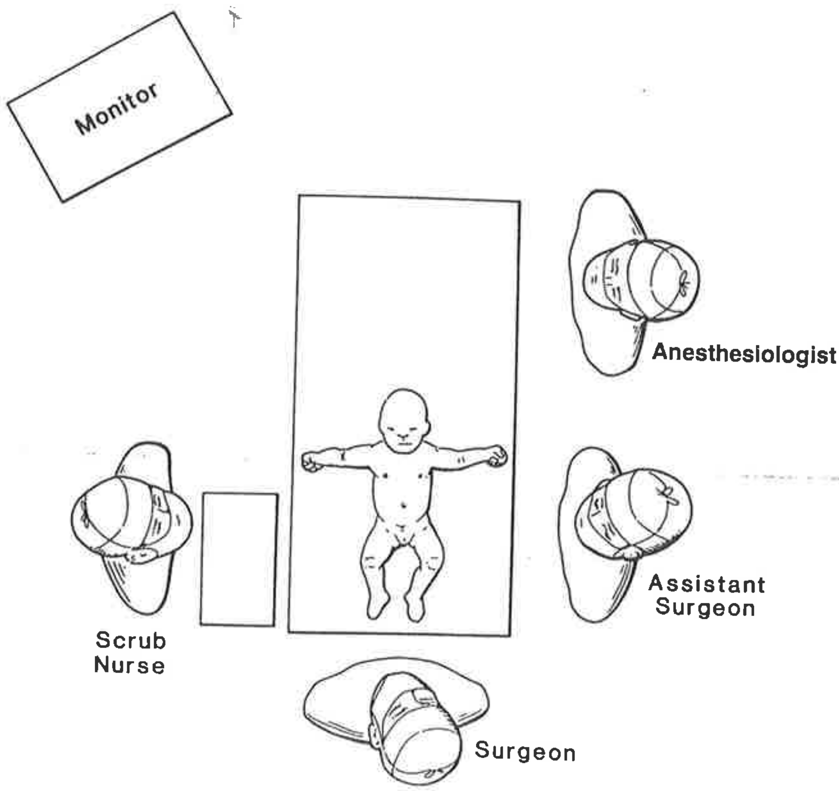


Figure 25-5
The operating room setup for performing laparoscopic pyloromyotomy in the infant.

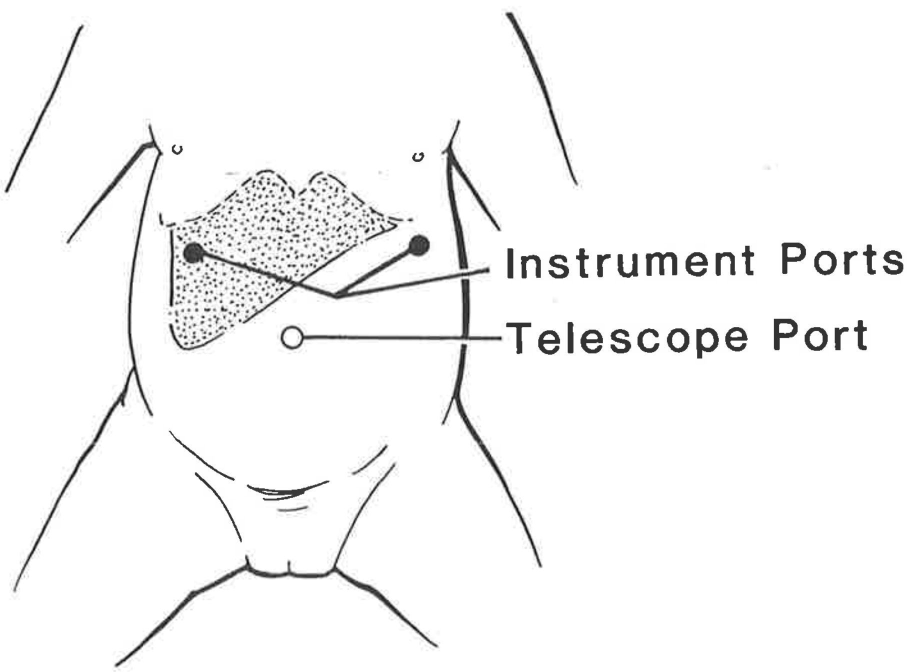


Figure 25-6
The placement of instrument and telescope ports for pyloromyotomy in the infant.

tween the umbilicus and the costal margin, lateral to the nipple line (Fig. 25-6).

The gastric antrum and pylorus are identified by retracting the free edge of the liver upward and away from the stomach with the right upper quadrant grasper. The transverse colon can occasionally obscure the view, but it can be swept inferiorly away from the operation field.

While the liver is retracted with the left upper quadrant port, the duodenum just distal to the vein of Mayo should be firmly grasped by the atraumatic graspers in the right upper quadrant port. Do not attempt to hold the pyloric tumor because the forceps will slip off the firm tumor, and it will be difficult if not impossible to incise the tumor owing to instrument clash.

The duodenum and pylorus are retracted inferiorly away from the liver edge. If the liver edge is still obscuring the vision, it can be swept upward and tucked under the pylorus momentarily with the left upper quadrant grabber. The extent of the tumor can be identified quite readily by "palpating" it with the left-sided atraumatic graspers. The normal antrum is easily indented, and there is an abrupt junction identifiable between it and the firm pyloric tumor.

The endotome is introduced through the left upper quadrant port; the blade advanced out of its sheath in its entirety. The seromyotomy should be started at the duodenal end. The incision is extended toward the antrum about 3 to 4 mm beyond the extent of the tumor (Fig. 25-7). Countertraction should be applied with the atraumatic graspers holding on to the duodenum. It is not possible to cut in the opposite

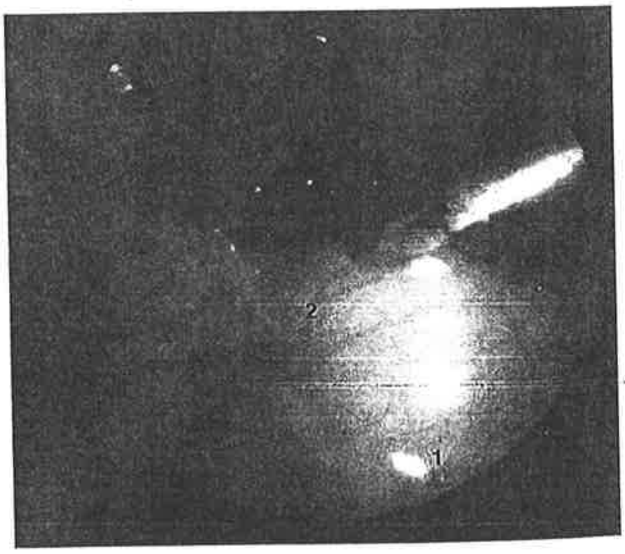


Figure 25-7
The initial incision in the pyloric tumor is made with an endotome. Note the vein of Mayo.
1 = Duodenum. 2 = Vein of Mayo. 3 = Antrum.

direction because the countertraction is important. The initial incision has to be deep or else it will be difficult to introduce the spreader.

The endotome is exchanged for the pyloric spreader, which is thrust through the incision until slight resistance from the intact mucosa is felt. It is important to ensure that the spreader is through the entire thickness of the tumor because the tumor will be otherwise difficult to split, and the edges will tear. The tumor is spread widely, beginning at the duodenal end. It is necessary to move the forceps further up the antral end to spread the most proximal fibers of the pyloric tumor. The mucosa should be inspected when the jaws of the spreader are wide apart. This is the best time to inspect it closely before the edges of the tumor bleed (Fig. 25-8). Sufficient air should be insufflated by the anesthesiologist via a nasogastric tube on completion of the pyloromyotomy to exclude an inadvertent perforation. The mucosa will be seen to bulge.

The abdomen is desufflated and the mini-incisions closed by repairing the linea alba with

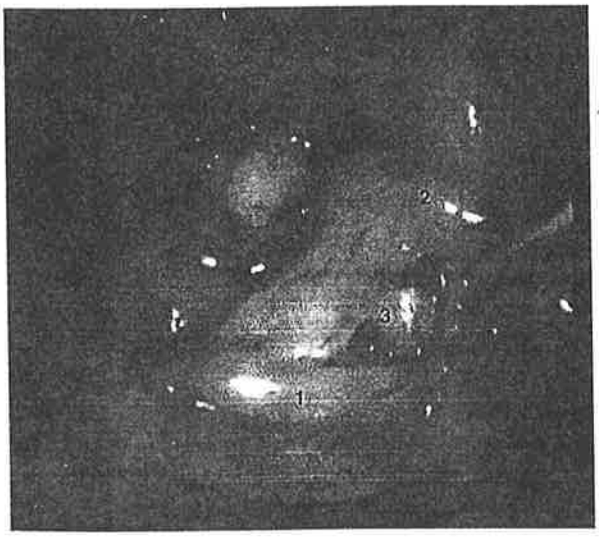


Figure 25-8
The spreader is shifted more proximally to complete pyloromyotomy at the antral end. Note that the mucosa is best inspected at this time.
1 = Duodenum. 2 = Antrum. 3 = Mucosa pouting through the myotomy.

one or two absorbable sutures and subcuticular skin closure. The patient can be fed the same day and discharged once feeding is established, usually on the following day. In our preliminary series, we have the impression that children do not vomit much following laparoscopic pyloromyotomy. This may be due to the minimal handling of the stomach. The entire operation is performed in situ as opposed to the open operation where considerable traction on the stomach is required to deliver the tumor.

Laparoscopy for Undescended Testes

Undescended testes is one of the most common conditions requiring surgical correction in the pediatric age group. However, in most children the testis is easily palpable in the superficial inguinal pouch and there is no indication for laparoscopy in these patients because orchidopexy is straightforward in these cases.

Laparoscopy is therefore indicated only in the patient with impalpable testis. The evidence is mounting that orchidopexy should be performed earlier to preserve spermatogenesis. We therefore recommend diagnostic laparoscopy at 12 months of age if the testes are still impalpable at that age. It is unrealistic to expect any further testicular descent beyond this age even in the extremely premature infant.

Diagnostic laparoscopy will establish if the testis is intraabdominal and offers the surgeon the option of ligating the testicular vessels to allow for collateral circulation to develop via the vessels to the vas. This enables the testis to be brought down on the vessel to the vas at some future date. The testicular vessels can be easily ligated without interfering with the operative field at subsequent open surgery.

Consent should be obtained for orchidectomy, open exploration, or ligation of the testicular vessels. The surgeon should stand on the contralateral side. We have found a 4-mm telescope more than adequate for diagnostic and therapeutic purposes. The video monitor should be positioned directly in front of the surgeon. The patient is tilted head down and rolled toward the surgeon to allow the viscera to fall away from the operation site. A diagnostic laparoscopy should be performed before establishing the instrument trocars. The internal inguinal ring should be inspected first. Its internal landmark is easily identified by following the external iliac vessels to their junction with the inferior epigastric vessels. If the vas deferens and testicular vessels are seen entering the internal inguinal ring, and if an indirect hernia is present, then the testis is intracanalicular (within a complete inguinal hernial sac). In this instance, you should proceed to an open orchidopexy, and the testes generally can be brought down satisfactorily without prior ligation of the testicular vessels.

If both the vas and testicular vessels enter the internal inguinal ring, the testis is either absent or it will be small and dysplastic. You should proceed to an open operation to explore the inguinal canal and perform an orchidectomy under the same anesthetic. If the vas or testicular vessels are not readily identifiable at the internal ring, then two 4-mm instrument ports should be inserted, one in the ipsilateral iliac fossa and the other in the ipsilateral upper quadrant of the abdomen.

It is probably easiest to look for the vas deferens first. It can usually be seen best where it crosses the lateral umbilical ligaments (umbilical arteries). The vas can then be followed laterally to either its testis or to its blind ending. If a small dysplastic testis is found, an orchidectomy can be performed using two Endoloops to ligate the vessels in continuity before excision of the testis. These dysplastic testes are usually very small and can be removed through the umbilicus without changing to a larger trocar.

If a sizable testes is located, the testicular vessels can be ligated. This can be performed without having to change to a larger instrument port. The peritoneum overlying the testicular vessels is divided by sharp Endoshears dissection. This allows the testicular artery to be picked up and two endoknots (with the needle removed) placed around it. An extracorporeal knot completes the procedure. The collateral supply will develop and orchidopexy performed later by bringing the testis down on the blood supply to the vas.

Laparoscopy for Pediatric Malignancies

Most pediatric malignancies are sarcomas. The management of pediatric malignancies has undergone significant changes in recent years. Chemotherapy in combination with local radiotherapy and limited excision preserves function without compromising the cure rate. This is now the favored treatment modality for many pediatric malignancies.

Laparoscopy is helpful in the staging of childhood tumors because the view through the endoscope is even better than that in an open operation. The only area inaccessible is the retroperitoneum. Many pediatric patients with malignancies have poor wound healing and suffer wound dehiscence or ventral hernias following open laparotomy owing to the chemotherapy regime. Laparoscopy eliminates the risk of dehiscence and ventral hernia.

Transperineal high dose radiotherapy with iridium wire has been employed in pelvic malignancies, but a major morbidity associated with this is ablation of ovarian function. This can be prevented by oophoropexy, which reduces the radiation dose to the ovary.

Oophoropexy

Oophoropexy can be a complex organizational problem, and it is essential to coordinate the services of the radiotherapist, the orthopedic surgeon, and the radiologist, as well as the pediatric surgeon, prior to surgery. The aim is to perform a staging laparoscopy, oophoropexy, and transperineal insertion of hollow needles for iridium needle brachytherapy. The patient will have to be immobilized in a hip spica, to prevent accidental dislodgment of the hollow needles, and, under the same anesthetic, moved to radiology to check the position of the needles with a computed tomography (CT) scan for calculation of the radiation dose.

The patient is positioned at the foot of the table in the Lloyd Davies position and the bladder catheterized with a silastic urethral Foley catheter. The patient is tilted head down and

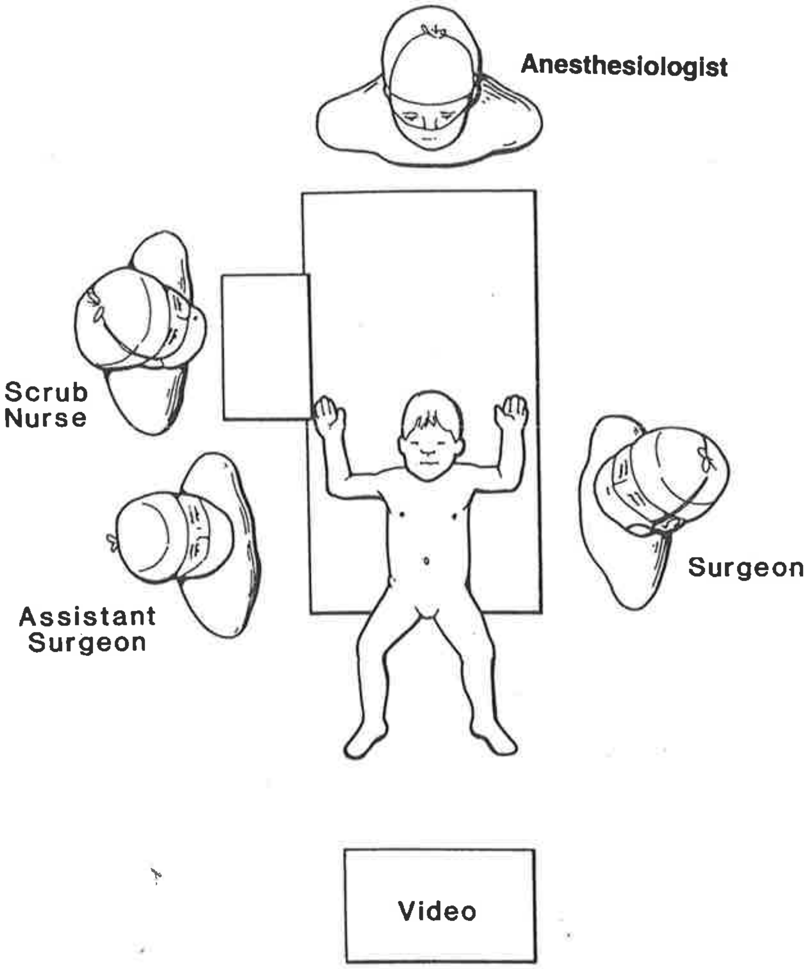


Figure 25-9
The patient position and operating room setup for oophoropexy before radiation treatment of the pelvis.

rolled toward the surgeon, to allow the viscera to be retracted away from the pelvis. The surgeon stands on the contralateral side of the ovary being fixed, and the video monitor is positioned between the patient's legs. The assistant stands on the ipsilateral side. The scrub nurse stands next to the assistant surgeon (Fig. 25-9).

The 4-mm telescope port is introduced through the umbilicus, using the technique previously described. Two more ports are established, one in each iliac fossa under direct internal video endoscopic control. Care is taken to avoid placing the trocars through the inferior epigastric vessels (which are prominent in this position). Atraumatic graspers are introduced into each instrument port, and a pelviscopy is performed. The atraumatic graspers can be used to manipulate the uterus, adnexa, and all intrapelvic viscera to allow careful inspection of the pelvic viscera and wall and any suspicious tissue or node biopsied. The ovary is easily identified as a small golden yellow organ by following the fallopian tube laterally. It should be grasped by the atraumatic forceps in the left-sided instrument port and retracted away from the pelvic brim into the abdomen proper (Fig. 25-10).

A laparoscopic suture is introduced through the right iliac fossa port and mounted on a 3-mm needle holder. The ovary is then grasped with the grasper, and one stitch is placed through the body of the ovary (Fig. 25-11). Sufficient length of suture is then drawn through the ovary to allow the end of the needle to be delivered extracorporeally. The peritoneum of the ipsilateral lateral abdominal wall 2 cm above

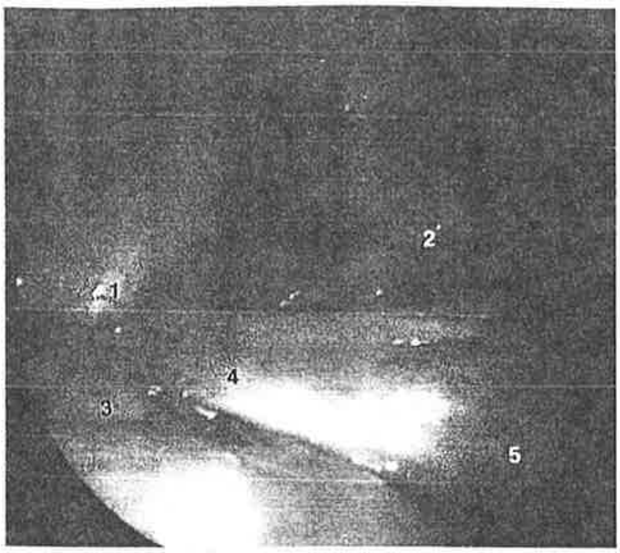


Figure 25-10
The ovary is grasped and pulled over the pelvic brim in order to fix it to the lateral abdominal wall.
1 = Preperitoneal radioactive implant. 2 = Pelvic brim. 3 = Rectum. 4 = Fallopian tube. 5 = Ovary.

the pelvic brim is picked up with the grasper and stitched with the same suture. An extracorporeal knot completes the fixation of the ovary to the lateral abdominal wall.

The umbilical telescope port is removed after both ovaries have been fixed, and the umbilical incision extended to allow the introduction of a 10-mm cannula. The telescope is reintroduced into either of the two instrument ports, a clip applicator is introduced through the 10-mm umbilical port, and a titanium clip applied onto the body of each ovary under direct visual control. This will allow the radiotherapist to calculate the dose to the ovary because the radio-opaque marker is visible on a plain x-ray. The hollow radiation needles are inserted under direct laparoscopic control, and the child's legs immobilized in a hip spica on completion of the procedure. The cosmetic advantage of this technique is apparent in Fig. 25-12.

Discussion

Although pediatric laparoscopic surgery is still in its infancy, the development of equipment suitable for smaller instrument ports will in-

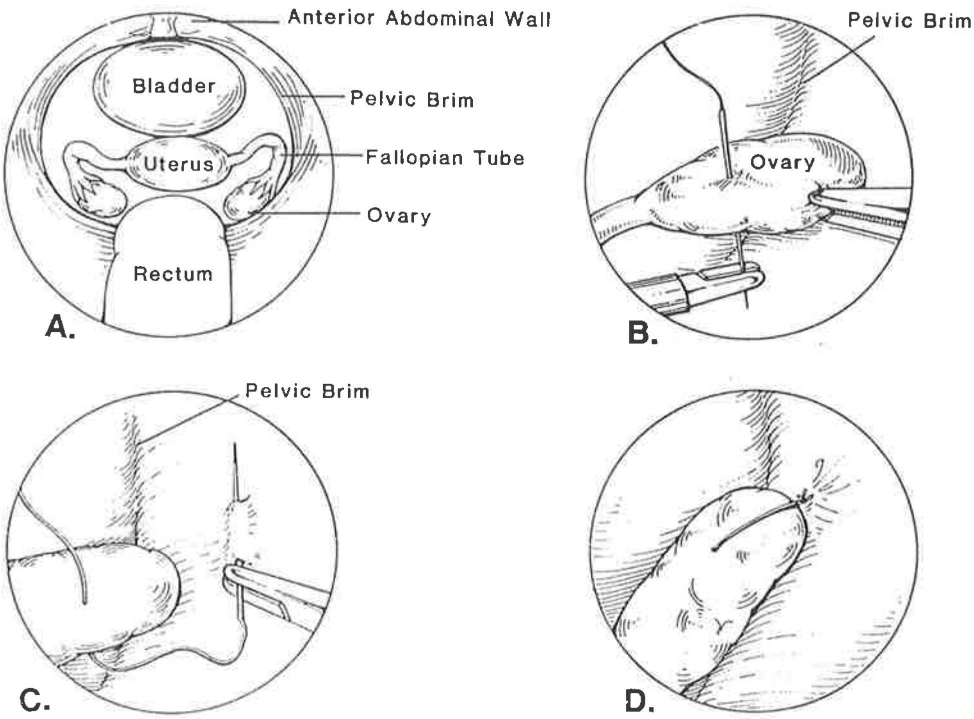


Figure 25-11
A. Normal pelvic anatomy. **B.** A laparoscopic suture is passed through the ovary and then **(C.)** through the lateral abdominal wall above the pelvic brim. **D.** An extracorporeal knot completes the fixation.

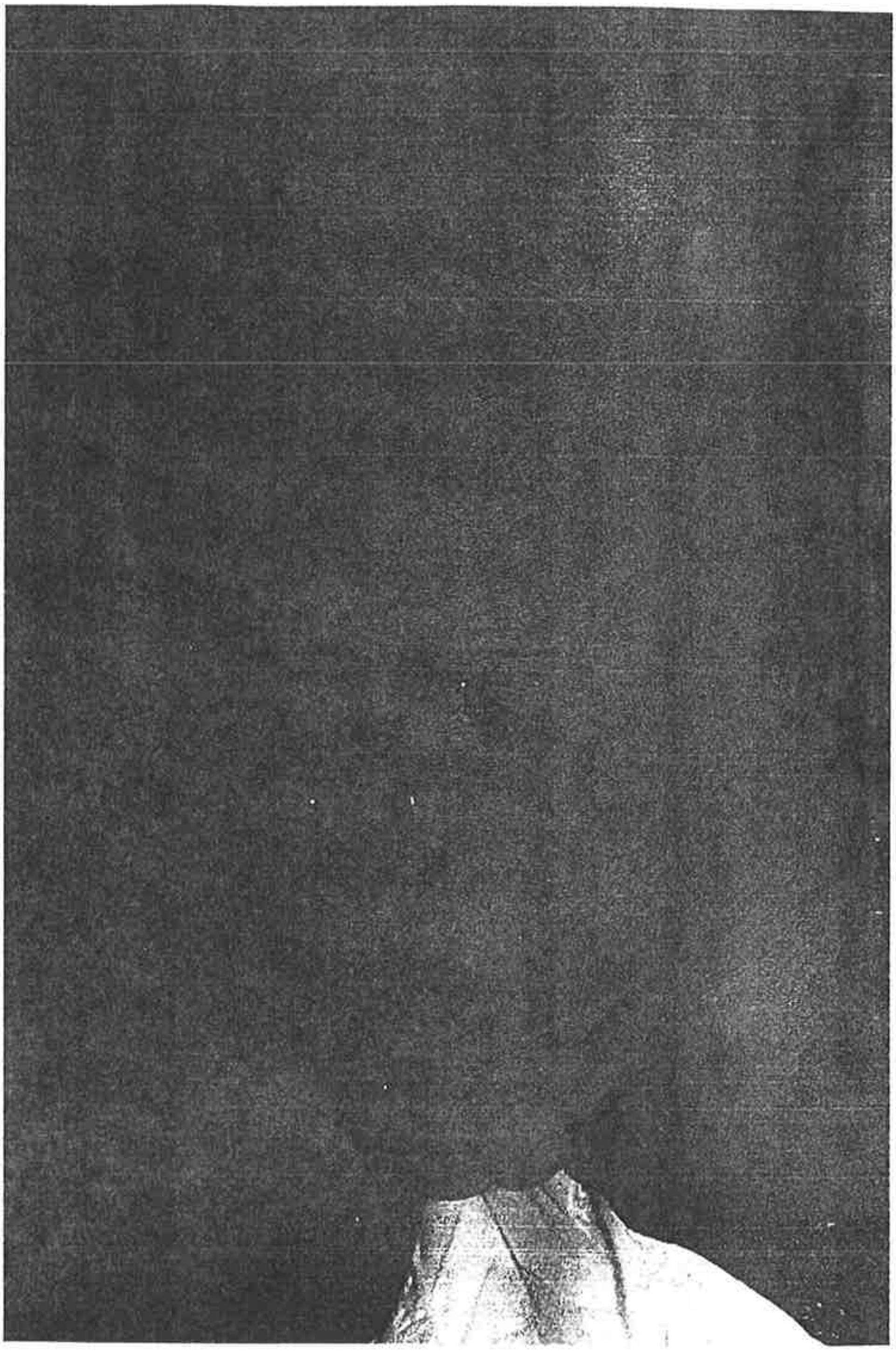


Figure 25-12
There is minimal cosmetic deformity seen with this technique.

evitably see laparoscopy being adopted by more pediatric surgeons as they develop skills in laparoscopy. There are a few important factors to consider when it comes to the performing of safe pediatric laparoscopy.

The fact that laparoscopic surgery is minimally invasive does not mean it is minor surgery. There is potential to cause great harm if improper techniques are employed, especially in small infants and babies simply because there is less room for error. Bleeding has more serious implications, not only because of the smaller blood volume but also because blood will absorb much of the reflected light, and this can compromise the illumination very quickly, especially when small endoscopes are used. The relative toughness of the infant peritoneum, the ease with which it strips off the anterior abdominal wall, and the proximity of underlying viscera make it potentially hazardous to use the Verres needle technique for establishing a pneumoperitoneum.

In spite of these relative drawbacks, the fact that laparoscopic surgery offers a means of performing surgical procedures with minimal iatrogenic trauma remains a very attractive proposition. This attraction will popularize laparoscopy in children in the future.

Bibliography

Alain JL et al: Extramucosal pyloromyotomy by laparoscopy. *J Pediatr Surg* 26:1191–1192, 1991.

Donaldson S, Kaplan H: Complications of treatment of Hodgkin's disease in children. *Cancer Treat Reports* 66(4):977–989, 1992.

Flamant F et al: Long-term sequelae of conservative treatment by surgery, brachytherapy and chemotherapy for vulval and vaginal rhabdomyosarcoma in children. *J Clin Oncol* 8(11):1847–1853, 1990.

Gans SL, Austin E: The techniques of laparoscopy, in Gans SL (ed): *Pediatric Endoscopy*. Orlando, FL, Grune & Stratton, 1983.

Gans SL, Berci G: Advances in endoscopy of infants and children. *J Pediatr Surg* 6:199–233, 1971.

Gans SL, Berci G: Peritoneoscopy in infants and children. *J Pediatr Surg* 8:399–405, 1973.

Hay SD et al: Sarcomas of the vagina and uterus: The intergroup rhabdomyosarcoma study. *J Paediatr Surg* 36:718–724, 1985.

Loughlin K et al: Genitourinary rhabdomyosarcoma in children. *Cancer* 63:1600–1606, 1989.

Newman KD et al: Laparoscopic cholecystectomy in pediatric patients. *J Pediatr Surg* 26:1184–1185, 1991.

Piouvost M et al: Transposition ovarienne percoelioscopique avant curietherapie dans les cancers du col uterin stade 1A et 1B. *J Gynecol Obstet Biol Reprod (Paris)* 30:361–365, 1991.

Rodgers BM et al: Laparoscopy in the diagnosis and treatment of malfunctioning ventriculoperitoneal shunt, in Gans SL (ed): *Pediatric Endoscopy*. Orlando, FL, Grune & Stratton, 1991.

Sackier JM: Editorial. *J Pediatr Surg* 26:1145–1147, 1991.

Spicer RD: Infantile hypertrophic pyloric stenosis: A review. *Br J Surg* 69:128–135, 1982.

Stauffer UG: Laparoscopy in hepatology and biliary diseases, in Gans SL (ed): *Pediatric Endoscopy*. Orlando, FL, Grune & Stratton, 1983.

Stillman R et al: Ovarian failure in long term survivors of childhood malignancy. *Am J Obstet Gynecol* 139(1):62–66, 1981.

Tan HL, Najmaldin A: Laparoscopic pyloromyotomy for infantile pyloric stenosis (in press). *J Pediatr Surg* (international).

Valla JS et al: Laparoscopic appendicectomy in children: Report of 465 cases. *Surg Laparosc Endosc* 1:166–172, 1991.

Waldschmidt J, Schier F: Laparoscopical surgery in neonates and infants. *Eur J Pediatr Surg* 1:145–150, 1991.

Wickham JEA: Editorial. *Minimally Invasive Ther* 1:1–5, 1991.

Zeidan B et al: Recent results of treatment of infantile pyloric stenosis. *Arch Dis Child* 63:1060–1064, 1988.

Laparoscopic appendicectomy

Laparoscopic appendicectomy was by this time being reported by many authors, but the EndoGIA, staplers and titanium clips to control the appendiceal artery were cumbersome, and required a large instrument port (10 – 12mm), which seemed to defeat the purpose of minimal access surgery.

The relative lack of space in a small abdomen also made it difficult to manipulate a large GIA endostapler or titanium clip applicator with any finesse, and it was felt that a better alternative existed.

Monopolar coagulation of the meso-appendix had been reported and indeed evaluated by myself, but the primary concern with this technique is unrecognised capacitive coupling, as there had been by then, several reports of remote site burns from capacitive coupling during laparoscopic surgery. At the same time, I had received a report of a Caecal burn at the base of the appendix from a surgeon using monopolar coagulation of the mesoappendix presumably due to the electric current being concentrated at the base of the appendix on its return path.

In the intervening years in the meantime, I had developed a technique of circumcision using bipolar forceps, coagulating and cutting the foreskin in a completely bloodless manner using a pair of needle point Adson's forceps fashioned for me by an instrument maker Alimtype, in Melbourne.

This technique of was demonstrated to the Karl Storz representative, and it was decided to make a prototype laparoscopic bipolar forceps with a tip somewhat like the needle point Adson's bipolar forceps, and to evaluate the use of this laparoscopically.

Again, by searching through the Karl Storz catalogue, the Vancaillie micro bi-polar forceps was found. Modifications of the Vancaillie forceps by sharpening the tip, stripping some of the insulation off the end and re-angling the tip, lead to the birth of the the "Tan" bi-polar forceps which is now manufactered by Karl Storz.

Initial clinical trials with this bi-polar forceps confirmed that it was indeed easy to use and was highly effective at a power setting of 15 Watts, and thus the laparoscopic "Bi-polar strip tease appendicectomy" technique was developed.

To lend weight to the fact that the technique was safe, it was important to demonstrate the blood supply of the appendix, and I therefore decided to obtain several open appendicectomies specimen from my other colleagues who were still performing open appendicectomies, requesting that the appendix and the mesoappendix be excised en bloc to study the vascular anatomy.

We cannulated the appendiceal arteries of five specimens received with a fine intravenous cannula, and filled the artery with Barium impregnated latex. An Xray of the Appendix was then taken which clearly demonstrated its vascular anatomy.

Although it was diabolically difficult to cannulate the appendiceal artery in an inflamed appendix, we nonetheless succeeded in cannulating the specimens, and were able to demonstrate that the blood supply to the appendix is quite uniform being supplied by one smallish vessel which ran along the free edge of the mesoappendix to its tip, with several fine branches supplying the rest of the appendix. It was clearly demonstrated that there were no major vessels, and that bipolar coagulation would adequately control these small vessels.

An Xray of the appendiceal blood supply was thus included in the paper on laparoscopic bi-polar strip tease appendicectomy.

To date, over 150 appendicectomies have been performed using this bipolar technique without a single bleeding episode. This technique has also been used in adolescent patients and is quick and cheap, as it only requires two endoloops to ligate the base of the appendix , sparing the cost of an endoGIA or Titanium clips.

Surgical Endoscopy

Surg Endosc (1995) 9: 1301–1303

Laparoscopic bipolar strip-tease appendicectomy

A new endosurgical technique

H. L. Tan, O. Segawa, J. E. Stein

Department of Surgery, The Royal Childrens Hospital, Flemington Road, Parkville, Victoria 3052, Melbourne, Australia

Received: 8 January 1975/Accepted: 19 April 1995

Abstract. Since its conception, several techniques have been described for laparoscopic appendicectomy. We describe a technique which utilizes a 5-mm bipolar forceps designed to coagulate and cut tissues at the same time; 50 pediatric patients underwent laparoscopic appendicectomy for acute appendicitis using this "stripping and teasing" technique. No bleeding complications occurred. There were only two postoperative abscesses in the series. We believe that the bipolar laparoscopic striptease appendicectomy technique as developed by the senior author is safe, quick, and effective, even for severe appendicitis.

Key words: Laparoscopic appendicectomy — Bipolar "striptease" technique

Since the first laparoscopic appendicectomy for acute appendicitis was reported by Semm in 1983 [5], a number of authors have reported performing the operation worldwide [1, 3, 7, 8]. However, there is considerable variation in the technique for performing the operation, each with its own inherent advantages or disadvantages. Our technique utilizes bipolar division of the mesoappendix which only requires one 10-mm Hasson umbilical port, one 4.5-mm suprapubic port, and a 6.0-mm paracolic port. The present report describes a safe and successful laparoscopic technique for laparoscopic appendicectomy.

Patients and methods

Fifty pediatric patients admitted between January 1992 and May 1994 under the senior author with clinical signs of acute appendicitis underwent successful laparoscopic appendicectomy. Patients who had diagnostic laparoscopy alone or who were converted to open operation (five patients) are excluded from this report as no attempt was made to proceed with laparoscopic appendicectomy in these patients because of the severity of the disease. The age at operation ranged from 2 to 16 years (average 11 years), and there was an equal sex distribution. All laparoscopic appendicectomies were either performed by the senior author or with his assistance. All specimens were studied histologically and all patients were administered perioperative intravenous antibiotics.

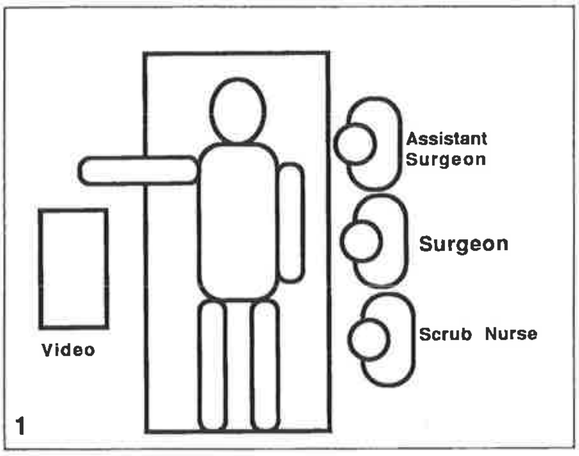
Correspondence to: H. L. Tan, Gleneagles Hospital, 6 Napier Road #07-06, Singapore 1025.

Technique

The patient is positioned supine and placed in a Trendelenburg position and rolled toward the left. The surgeon and assistant both stand on the left side with the scrub nurse at the foot of the patient. The video monitor is placed directly in front of the surgeon on the patient's right (Fig. 1).

A 10-mm Hasson cannula is inserted through a small transverse incision in the linea alba by making a circumumbilical skin crease incision. The Hasson port is secured by using 0 Vicryl purse string suture in the linea alba, which not only helps to secure the pneumoperitoneum but also serves to close the defect at the end of the procedure. An insufflation pressure of 12 mmHg is used and a 5-mm direct-viewing telescope is then inserted. Two other ports, a 4.5-mm suprapubic midline port and a 6.0-mm right paracolic port are introduced under direct video endoscopy to avoid injury to either the bladder or the underlying viscera (Fig. 2).

An atraumatic grasper is inserted into each of these ports and the cecum and appendix are then identified. If the appendix is normal in appearance, an exploratory laparoscopy is performed to exclude other pathology, especially tubo-ovarian pathology in the female. A conscious decision is then made to perform laparoscopic appendicectomy even in those that appeared macroscopically normal, if no other pathology is found.



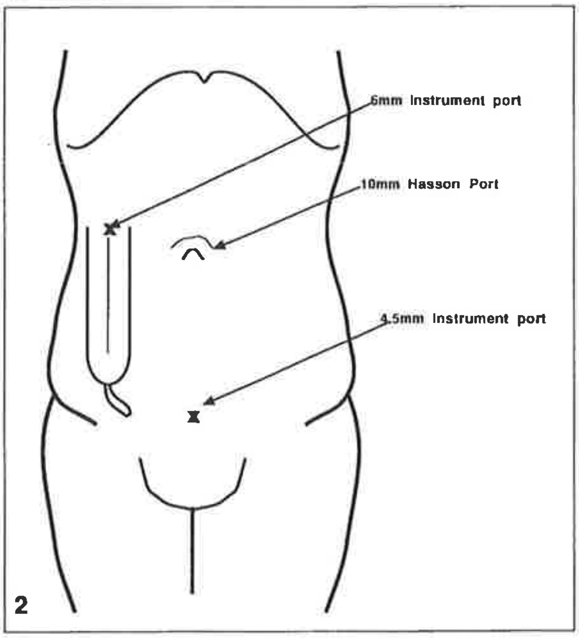
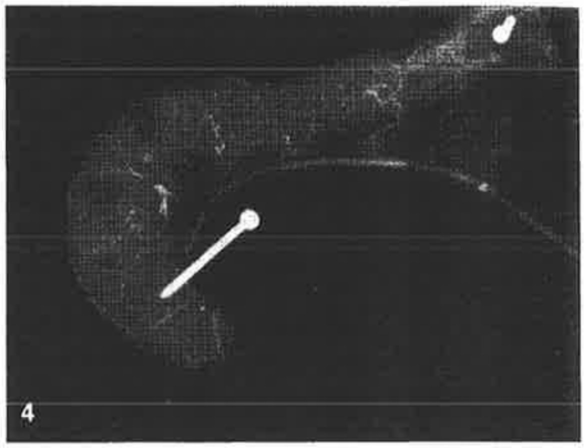


Fig. 1. Theater layout for laparoscopic appendectomy.
Fig. 2. Port positions for laparoscopic appendectomy.



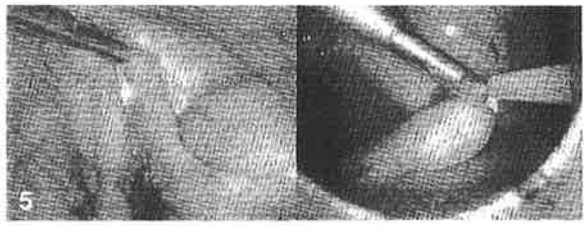


Fig. 3. Mesoappendix being stripped from appendix using "pecking" action.
Fig. 4. Contrast injection of mesoappendiceal artery demonstrating vascular anatomy. Note the fine vessels at the mesoappendix/appendix margin.
Fig. 5. Demonstrating completely skeletonized appendix and ligation of stump with extracorporeal ligature.

A ratchetted grasper is passed through the suprapubic port to grasp the tip of the appendix. If the appendix is retrocecal in position, it is necessary to mobilize the cecum by dividing its peritoneal attachment. The appendix can then usually be mobilized once the cecum is freed. We have yet to perform a retrograde laparoscopic appendicectomy if the cecum is mobilized sufficiently.

Traction is applied to the tip of the appendix to demonstrate the mesoappendix, which is kept taut.

A special purpose-built bipolar forceps (Tan bipolar forceps—Karl Storz) is passed through the right paracolic port and the mesoappendix is coagulated and "stripped and teased" from the appendix by using a pecking action (Fig. 3). The bipolar forceps has been specially designed to coagulate and divide tissue without the need to interchange instruments.

The striptease technique can control vessels up to 1 mm in diameter, and we have not encountered any bleeding from the mesoappendix, particularly if the appendix is skeletonized right at the meso-appendiceal border, as the vessels here are generally very fine. This is aptly demonstrated by a contrast injection of the mesoappendiceal artery in patients who have had open appendicectomy and the specimen removed en bloc for this study (Fig. 4).

By using this "striptease" action, the appendix is skeletonized down to the base of the appendix (Fig. 5), which is then ligated with two PDS-Endoloops. The appendix is then divided with the same bipolar forceps and delivered through the 10-mm Hasson cannula after interchanging the telescope through the right paracolic port. If the appendix is gangrenous, perforated, or associated with an appendiceal abscess, laparoscopic surgical debridement is performed and the peritoneal cavity is thoroughly irrigated with a copious amount of normal saline prior to completion.

Table 1. Summary of cases[a]

10	2	2	7	21	8
Normal	Enterobiasis	Chronic appendicitis	Phlegmonous	Catarrhal	Gangrenous or perforated

[a] Total no. cases: 50. Average operative time: 40 min. Complications: 2 postoperative abscesses. Conversions: 5. No bleeding complications

Results

Fifty patients underwent laparoscopic bipolar appendicectomy. Of these, 21 were catarrhal, 7 were phlegmonous, and 8 were gangrenous or perforated. There were two patients with chronic appendicitis, two with enterobiasis, and ten were normal. The average operating time was 40 min for all cases. There were only 2 (4%) postoperative abscesses. There was no bleeding and no wound infection. There were no laparoscopically related complications (Table 1).

Discussion

Many techniques have been described for the performance of laparoscopic appendicectomy. Lobe and Whitcombe have both described the use of endostapler [2] to control the mesoappendix and the appendix while endoscopic titanium clips, laser [4], and extracorporeal endoknots [6] have also been described for ligating the mesoappendix en masse. Monopolar electrocautery has also been described to coagulate and cut the mesoappendix, but this is potentially hazardous in appendicectomy as the return path for the monopolar current is through the base of the appendix and cecal perforation can occur (W.D.A. Ford, Adelaide Children's Hospital, personal communication).

We have developed a safe, highly effective, and efficient method of coagulating the mesoappendix using a special purpose-built bipolar forceps that cuts and coagulates concurrently. This bipolar technique has several advantages. Only one 10-mm cannula, placed in the umbilicus, is required. By using a 5-mm telescope, the right paracolic port can be used to insert the telescope while the appendix is delivered through the 10-mm Hasson cannula.

One of the major disadvantages of laparoscopic appendicectomy is the high cost of disposable instruments, especially if one uses the endo-GIA stapler or titanium clips. Our technique only requires two endoloops, which can be passed through the 6-mm right upper quadrant port, and the fact that a second large cannula is not required for titanium clip or endolinear stapler makes for better cosmesis and less expense. While the relative size of the instrument cannulae may not be an important consideration in adults, it is important to reduce the size of the cannula in pediatric laparoscopic procedures, as larger cannulae cause excessive gas leak, which can lead to hypothermia in children.

This paper describes a technique of laparoscopic bipolar appendicectomy which we believe to be safe and effective in children. We believe this technique can be used in adults as well, as we have now had experience with adolescent children where the appendices and anatomy are no different from adults. The bipolar striptease technique has also been used to resect solid tissue bloodlessly, such as for laparoscopic heminephrectomy.

References

1. Gotz F, Pier A, Bacher C (1990) Modified laparoscopic appendectomy in surgery. A report on 388 operations. Surg Endosc 4: 6–9
2. Lobe TE, Schropp KP (1994) Pediatric laparoscopy and thoracoscopy, Suanders, Philadelphia
3. Oregan PJ (1991) Laparoscopic appendectomy. Can J Surg 34: 256–258
4. Schropp KP, Lobe TE (1994) Laparoscopic appendectomy. In: George W, Holcomb III (eds) Pediatric Endoscopic Surgery. Appleton & Lange, Norwalk CT, pp 21–27
5. Semm K (1983). Endoscopic appendectomy. Endoscopy 15: 59–64
6. Semm K, Freys I (1991). Endoscopic appendectomy: technical operative steps. Min Inv Ther 1: 41–50
7. Valla JS, Limonne B, Valla V, Montupet P, Daoud N, Grinda A, Chavriet T (1991) Laparoscopic appendectomy in children: Report of 465 cases. Surg Laparosc Endosc 1: 166–172
8. Wilson T (1986) Laparoscopically-assisted appendectomies. Med J Aust 145: 551

Role of Laparoscopy in the Management of Recurrent Abdominal Pain in Children

Role of Laparoscopy in the Management of Recurrent Abdominal Pain in Children

H. L. Tan and J. M. Smart, Gleneagles Medical Centre, Singapore.

Recurrent abdominal pain is a very common problem in childhood. While the pains are usually non-organic in nature, there remains a small but significant group of patients in whom it is difficult to exclude surgical pathology. These groups have in the past been considered for exploratory laparotomy. We investigated the role of diagnostic laparoscopy in the management of these patients and report our experience. Fifteen patients presented with recurrent pain in the right iliac fossa where symptoms were sufficient to interfere with lifestyle. All patients underwent diagnostic laparoscopy and laparoscopic appendicectomy. Appendiceal faecoliths were identified in four patients and histological evidence of previous inflammation was documented in four others. One patient had appendiceal adhesions with a histologically normal appendix. The remaining six patients had had no appendiceal or any other pathology. Nine other patients who had open surgery previously also underwent diagnostic laparoscopy for recurrent abdominal pain. Six patients were found to have adhesions that were successfully lysed laparoscopically with subsequent relief of symptoms. Three patients re-presented with further abdominal pain within four to 14 months. Our early experience with diagnostic laparoscopy suggests that it is a useful diagnostic and therapeutic tool in the management of recurrent abdominal pain during childhood. ***(Asian J. Surgery 1998;21(1):47–50)***

Recurrent abdominal pain (RAP) in children is a common phenomenon said to occur in approximately 10% of school-aged children.[1] The pain varies in nature, severity and duration and is usually managed on an outpatient basis. Such children pose a significant management problem, especially when marked disruption to the lifestyle of the child or the family results. In the past, when all relevant tests were normal, such children were labelled as having psychogenic or functional pains and managed accordingly. Some patients have even been prescribed psychotropic medication, often with little or no relief.

Although surgical evaluation is sometimes necessary to exclude organic cause, there is often a reluctance to submit patients to exploratory laparotomy when hard evidence of organic pathology is lacking: exploratory laparotomy is often considered as a last resort in these patients.

The advent of diagnostic and therapeutic laparoscopy has lead us to consider its role in the management of children with RAP.

Address reprint requests to Dr. H L Tan,
Gleneagles Medical Centre #07-06, 6 Napier Road,
Singapore 258499, Singapore.
Date of acceptance: 18th October 1996

Patients and Methods

Twenty-four patients underwent diagnostic laparoscopy for severe RAP between 1990 and October 1993 at the Royal Children's Hospital in Melbourne, Australia. Ages ranged from four to 18 years. Patients were divided into two groups: group A consisted of 15 patients with a recurrent right iliac fossa (RIF) pain and group B consisted of nine patients with a history of RAP following previous abdominal surgery. Children in both groups had symptoms severe enough to interfere with lifestyle, including poor attendance at school.

All children had undergone previous investigations including full blood count, erythrocyte sedimentation rate, liver function tests and serum amylase, and had had routine urine analysis and faecal examination. In addition, plain radiographs of the abdomen and abdominal ultrasound were performed, and where evidence of constipation was found, active medical treatment was instituted. Most children had also been referred for gastroenterological opinion.

Persistence of abdominal pain interfering with lifestyle despite adequate management of constipation was an indication for laparoscopic intervention.

Diagnostic laparoscopy

Diagnostic laparoscopy was performed using an open laparoscopy technique with carbon dioxide insufflation. The entire abdominal cavity was inspected to exclude chronic inflammatory bowel disease or other pathology, such as Meckel's diverticulum; the pelvis was inspected in female patients. Elective appendicectomy was then performed in all patients in group A and all surgical specimens were sent for histological examination.

In group B, diagnostic laparoscopy was performed to exclude intra-abdominal adhesions as the cause and if adhesions were encountered, adhesiolysis was performed laparoscopically.

Results

Group A

Fifteen patients with recurrent RIF pain aged between six and 15 years underwent diagnostic laparoscopy and laparoscopic appendicectomy after routine investigations to exclude other causes. There were seven males and eight females.

No unexpected pathology was found in any patient. Seven appendices were reported as being histologically normal, although one patient had a fibrous band extending from the appendix to the caecum indicative of previous inflammation. Four appendices examined had histological features of previous inflammation with intramural fibrosis or fibrous obliteration of the appendiceal lumen. One of these was diagnosed as 'resolving appendicitis'. Four other appendices had faecoliths but were otherwise normal.

Interestingly, only 47% of patients in this group had normal appendices, while 53% had pathology that could have accounted for the RAP. All patients, including those with normal appendices, remained symptom free following appendicectomy (Table 1).

Table 1. Results of laparoscopic appendicectomy in children with recurrent right iliac fossa pain

	Total (n)	Normal (n)	Histology of previous inflammation (n)	Faecolith (n)
Male	7	3	3	1
Female	8	4	1	3
Total	15	7	4	4

Group B

Nine patients, aged from four to 18 years, with severe RAP following previous abdominal surgery underwent diagnostic laparoscopy. There were eight females and one male. Each patient had previously been investigated with plain abdominal radiograph with or without contrast media; only three patients had radiological features suggestive of dilated small bowel.

At laparoscopy, adhesions were found in seven patients, two with adhesions to the undersurface of a previous scar (Fig. 1) and five with extensive adhesions, which were all successfully lysed laparoscopically. Two patients were free of adhesions; these patients were successfully managed for non-organic pains (Table 2).

Figure. Typical adhesions of an appendix to a previous scar.

Table 2. Results of laparoscopic appendicectomy in children with recurrent abdominal pain following previous abdominal surgery

	Total (n)	No adhesions (n)	Minor adhesions (n)	Extensive adhesions (n)
Male	1	1	0	0
Female	8	1	2	5
Total	9	2	2	5

Three of the patients with extensive adhesions re-presented between four and 14 months postoperatively with reccurent pain. Two of these had repeat laparoscopies; one patient had recurrent omental adhesions, the other was adhesion free. The third patient was diagnosed and treated for constipation, with no further problems. The remaining six patients in group B are free of pain.

Discussion

Apley defined recurrent abdominal pain as that occurring in children who have had three distinct attacks of abdominal pain in a three-month period.[2] The dilemma in the management of such children is in distinguishing those with organic versus non-organic aetiological factors.

Woodward et al suggested that it seemed sensible to perform elective appendicectomy on children on their third admission for nonspecific abdominal pains.[3] However, there has been a natural reluctance to go this extra step for fear of putting a patient through a 'needless surgical procedure'. Additionally, unless one performs an extensive incision, it is not possible to explore the entire abdominal cavity adequately through an appendicectomy incision.

As an example of the difficulty management of these patients, one 13-year-old boy with recurrent RIF pain, nausea and loss of weight had been extensively investigated with negative results, and was referred for psychiatric review and commenced on antidepressants, without relief of symptoms. There was reluctance to perform a laparotomy on this patient, but the family were happy to consent to a diagnostic laparoscopy. At surgery, no pathology was identified, but a high retrocaecal appendix was removed laparoscopically. Histologically, the appendix showed features of past inflammation with fibrosis, sufficient to explain his symptoms. Appendicectomy led to resolution of pain and cessation of antidepressant therapy. This case, of course, is uncommon but exemplifies the diagnostic and management dilemma for children with recurrent abdominal pain.

The advent of laparoscopy as a safe, effective and minimally invasive diagnostic and therapeutic tool with low associated morbidity[4] has led us to reconsider the traditional indication for surgical intervention in children with RAP. When performed by adequately trained surgeons,[5,6] laparoscopy has many advantages over conventional surgery: less postoperative pain, shorter recovery time and hospitalization, better cosmetic results, fewer complications, early ambulation and earlier resumption of a normal lifestyle. Furthermore, the diagnostic accuracy of laparoscopy in the evaluation of acute abdominal pain has been reported to be as high as 99%,[7] as is the success rate of laparoscopic appendicectomy.[8] It has also been shown to demonstrate more sensitivity, specificity and cost-effectiveness in diagnostic situations.[9]

The patients who underwent diagnostic laparoscopy in our study comprised a small proportion of children presenting with RAP. Most patients in our study satisfied Apley's criteria and additionally had either had recurrent RIF pain or a previous laparotomy. The dilemma facing most clinicians is the child presenting with recurrent RIF pain for whom the patient and family are concerned about the possibility of the 'grumbling appendix'. There has always been a reluctance to subject these children to laparotomy.

We have demonstrated that a significant proportion of such children have appendiceal pathology accounting for pain, as judged by histological appearance of specimens.

Similarly, while adhesive intestinal obstruction in children has been successfully treated laparoscopically in a significant number of patients, avoiding the need for laparotomy,[10] our study suggests that adhesions to the anterior abdominal wall are a significant cause of recurrent wound pain, as lysis of these adhesions has led to immediate relief of such pain.

One often feels uneasy about labelling a child with severe RAP as having a functional illness, as it is still difficult with conventional organ imaging confidently to exclude surgical pathology. Laparoscopy has, however, added a new dimension by allowing a thorough examination of the entire abdominal cavity to exclude chronic inflammatory bowel disease, Meckel's diverticulum, and pelvic and ovarian pathology with certainty.

This study demonstrates that laparoscopy can be a useful diagnostic and therapeutic tool in the management of childhood RAP.

References

1. Mammen A, Hutson JM. Clinical Paediatric Surgery. Oxford: Blackwell Scientific Publications, 1992.
2. Apley J. The Child with Abdominal Pain. Oxford: Blackwell Scientific Publications, 1975.
3. Woodward AA. Abdominal pain in children. In: Hutson JM, Beasley SW, Woodward AA, eds. Jones Clinical Paediatric Surgery. Melbourne: Blackwell Scientific Publications, 1992,131–132.
4. Easter DW, Cuschieri A, Nathanson LK, Lavelle-Jones M. The utility of diagnostic laparoscopy for abdominal disorders: audit of 120 patients. Arch Surg 1992;127:379–383.
5. Azura-Fernandez H, Skinfield-Fernandez FJ, et al. Laparoscopy surgery: experience with the first paediatric surgical patients. Bol Med Hosp Infant Mex 1993;50:39–43.
6. Gilchrist BF, Lobe TE, Schropp KP, et al. Is there a role for laparoscopic appendicectomy in pediatric surgery? J Pediatr Surg 1992;27:209–214.
7. Graham A, Henley C, Mobley J. Laparoscopic evaluation of acute abdominal pain. J Laparoendosc Surg 1991;1: 165–168.
8. Browne DS. Laparoscopic-guided appendicectomy: a study of 100 consecutive cases. Aust N Z J Obstet Gynaecol 1990;30:231–233.
9. Sessions SC, von Rueden DG, Uribe A. Diagnostic laparoscopy. J Laparoendosc Surg 1991;1:319–324.
10. Tan HL, Mammen A, Hutson JM. Initial experience with laparoscopic adhesiolysis in children. Pediatr Surg Int 1994;9:561–563.

GASLINI 1995;27:41-6

Laparoscopic surgery: anatomic and physiological aspects in children

H. L. TAN

Although Semm was the first surgeon to describe complex laparoscopic procedures, it was Mouret who led the revolution in general surgery when he described Laparoscopic Cholecystectomy that has become universally accepted today as the treatment of choice for cholelithiasis. Paediatric surgeons have been a little more reluctant to embrace Laparoscopic surgery until relatively recently. One important problem encountered at the beginning was the size of the instrumentation available. It made no sense to use adult telescopes and standard 10 mm cannulas for laparoscopic operations on infants when many paediatric procedures are performed through incisions that are often not much more than 2-3 cm long. This problem has since been resolved by the development and design of infant operative laparoscopic instruments also keeping in mind that children cannot be seen as a small adult and there are important anatomical and physiological differences. Notwithstanding these differences, many advances have now been made in Paediatric laparoscopic surgery and sufficient experience has been gained to make some preliminary assumptions. Contrary to expectations, diagnostic laparoscopy are not done as commonly: the easily availability of CT scanning, ultrasound and MRi has permitted such an accurate and a totally non invasive means of delineating intra-coelomic pathology that there has been rarely a need to perform laparoscopy. The need for a large tissue core has lead to the increasing use of endoscopic techniques not only to stage malignancies. but to obtain a sufficiently large tissue sample for cell culture. It is too early to draw conclusions about the relative merit or otherwise of laparoscopic versus open operations. The question that needs to be asked is whether it necessary for the results of laparoscopic procedures to be better than open operation. The important consideration surely is that it has to be safe. Like in adult surgical practice, laparoscopic surgery is here to stay.

From the Department of Pediatric Surgery, Royal Children's Hospital Melbourne, Australia

Address reprint requests to: Hock L. Tan - Gleneagles Medical Centre, 6 Napier Road - 03-03 - Singapore 1025.

Key words: **Laparoscopic surgery - Paediatric surgery.**

Laparoscopy in Paediatric Surgery in not new.

Drs. Stephen Gans and George Berci in 1970 investigated laparoscopic applications in Children and reported it to be a useful diagnostic tool. It was not possible with the technology available then to perform anything more than a diagnostic laparoscopic examination or simple biopsies.

Unfortunately, 1970 also saw the introduction of CT scanner by EMI. This together with the later development of abdominal ultrasound imaging provided a very accurate means of diagnosing abdominal pathology without having to resort to laparoscopy and hence it did not become popular except perhaps for the diagnosis of the intra-abdominal testis.

Parallel development of new technology in the last decade increased the potential for laparoscopy to be much more than a simple diagnostic tool. Very high intensity light sources such as the Xenon or Metal Halide lamps, the availability of high resolution video monitors and miniature charged coupled device (CCD) video cameras permitted very high quality video images to be transmitted in low lighting conditions allowing large cavities to be examined with such clarity and resolution that a completely new dimension was added to endoscopy. This allowed a high resolution image from a camera to be attached to the eyepiece which could be now be held by an assistant, enabling the surgeon to operate with both hands as in open surgery, and signified a major advance in the ability to manipulate tissues and perform complex operative procedures endoscopically.

Although Dr Kurt Semm from Keil was the first endoscopist to describe complex laparoscopic procedures such as laparoscopic Appendicectomy and Hysterectomy, it was Dr. Phillip Mouret who led the revolution in Adult General Surgery when he described Laparoscopic Cholecystectomy in 1987. Drs Dubois, Perissat and Reddick subsequently popularised laparoscopic Cholecystectomy and in spite of initial resistance and outrage at the introduction of a radically new treatment, it has become universally accepted today by adult general surgeons as the treatment of choice for cholelithiasis.

Paediatric surgeons have been a little more reluctant to embrace Laparoscopic surgery until relatively recently and for very good reasons. The introduction of a Veress needle was still seen as a potentially hazardous procedure in a small infant, but this was soon overcome by the adoption by most centres of the open laparoscopy or "Hasson" method, reducing the risk of inadvertent visceral or vascular damage.

Another problem encountered was the size of the laparoscopic instrumentation available, as the adult instruments were unsuitable for use in small infants. It made no sense to use adult telescopes and standard 10 mm cannulas for laparoscopic operations on infants when many paediatric procedures are performed through incisions that are often not much more than 2-3 cm long. Such large instruments and cannulae also lead to a rapid and substantial loss of pneumoperitoneum in a small cavity that will only accommodate 500 ml of CO_2.

The problem of inadequate instrumentation has since been resolved by the development and design of infant operative laparoscopic instruments which has extended laparoscopic surgery to infants, and we have seen increasing acceptance of Paediatric Laparoscopic Surgery in the past two years.

Children cannot be seen as a small adult and there are important anatomical and physiological differences.

Anatomic differences

The umbilicus

The umbilicus is very busy in a neonate. The two umbilical arteries (lateral umbilical ligaments) and the umbilical vein (ligamentum teres) are not obliterated for several weeks. There is a potential risk of gas embolism if CO_2 is insufflated unknowingly into these unobliterated vessels by any blind puncture technique. The urachus is also a prominent structure and the combination of the umbilical arteries and urachus makes the infra-umbilical a busy region in an infant. It therefore makes more sense to perform a supra-umbilical rather than an infra-umbilical approach when establishing the primary trocar.

The neonatal bladder is an intra-abdominal organ. This presents special problems in cannula placement in the supra pubic area, as not only is the bladder more susceptible to inadvertent perforation in infants, but the peritoneum is also especially lax in the supra pubic region causing the parietal peritoneum to tent away from the advancing trocar making the introduction of supra pubic trocars more difficult.

The upper abdomen

The falciform ligament and the umbilical vein remnant (ligamentum teres) are very prominent structures in infants and children. A Veress needle introduced in the midline in the upper abdomen will dissect between the two loosely attached folds of peritoneum forming the falciform ligament, and it is easy to be "lost" in this fold. Similarly, when performing a Hasson Open Laparoscopy, it is easier to make a transverse incision in the linea alba to gain entry into the abdominal cavity rather than use a mid line incision as practiced by adults surgeons, for the same reason.

The liver

The neonatal and infant liver overhangs the costal margin, and its lower margin reaches the umbilicus in neonates. There is a risk of injury to the liver if blind punctures are made in the upper abdomen in very young infants. Even under direct internal endoscopic control, the tip of the cannulas can be perilously close to the anterior surface of the liver.

Relationship of other abdominal viscera

The inferior vena cava and aorta is barely I cm away from the anterior abdominal wall.

Because of these differences highlighted, we do not recommend the use of a Veress needle in small babies and infants. We have a universal rule to use only the open Laparoscopy technique in our institution and have not to date witnessed any trocar injuries in any patient.

Size of the pediatric abdomen

There is very little room in a baby to perform certain laparoscopic procedures such as intracorporeal knot tying, and the proximity of adjoining viscera makes the use diathermy more hazardous.

However the small size also means that is very easy for the surgeon to have easy visual access to every abdominal viscera apart from the retroperitoneal structures.

Physiological differences

Respiration

Infant breathing is predominantly diaphragmatic, and the distension of the abdominal cavity in small infants will lead to splinting of the diaphragm leading to increased ventilation requirements. Not withstanding this, it is still possible to perform safe laparoscopic insufflation in neonates if the insufflation pressures are kept below 10 mmHg. Some authors have advocated using a lower abdominal insufflation pressure, but this makes the introduction of trocars and cannulae difficult, and there is little to be gained from having too low a pressure.

Hypothermia

Because the insufflated CO_2 is cold, there is a potential for small children to become hypothermic during laparoscopic surgery especially if high gas flows are used. The answer to safe laparoscopic surgery in infants is not to use high insufflation but instead to pay attention to details to minimize gas leak by ensuring that all cannulae and instruments have adequate and sound gas seals.

Notwithstanding these differences, many advances have now been made in Paediatric laparoscopic surgery, and sufficient experience has been gained to make some preliminary assumptions about Paediatric Laparoscopic Surgery.

Patients and methods

Laparoscopic procedures in children

Diagnostic laparoscopy.—Contrary to expectations, diagnostic laparoscopy are not done as commonly as one would expect at the Royal Children's Hospital. The easily availability of CT scanning, ultrasound and MRi has permitted such an accurate and a totally non invasive means of delineating intra-coelomic pathology that there has been rarely a need to perform laparoscopy. Where it has been shown to be useful has been in three areas namely the impalpable testis, in childhood malignancies and in the diagnosis of chronic inflammatory bowel disease.

Laparoscopy for undescended testis.—Although undescended testis remain one of the commonest paediatric surgical conditions, the majority of undescended testis are in the superficial inguinal pouch or within the inguinal canal, and only 1 to 3% of undescended testis are truly intra-abdominal and requiring laparoscopy. Our current indication for laparoscopy is in the patient in whom neither the cord nor the testis can be felt in the inguinal canal on EUA. If either of the testis or the cord can be felt, it has been our experience that one will either find an emergent testis which can be brought down by conventional orchidopexy or else it is likely to be an atrophic testis.

Using our current indications, we have only performed 24 diagnostic laparoscopies for the truly impalpable testis. In Twelve of 24, a blind ending vas was found confirming the diagnosis of the disappearing testis. The vestigial cord structures were excised in all these cases confirming the diagnosis. Only, eight patient had an abdominal testis and all underwent a staged Fowler Stephens procedure with two testicular atrophy to date. Four patients were found to have emergent testis lying within the inguinal canal and all these patients had an open orchidopexy where the testis were successfully brought down.

Laparoscopy in childhood malignancy.—This may yet prove to be an important indication for diagnostic and therapeutic laparoscopy. While percutaneous needle biopsies have been used in our institution for histological diagnosis of childhood malignancies, the need for a large tissue core has lead to the increasing use of endoscopic techniques not only to stage malignancies, but to obtain a sufficiently large tissue sample for cell culture.

We have also employed endoscopic techniques in conjunction with conventional organ imaging to stage tumours and are in the process of evaluating its usefulness as a staging modality.

One of the most useful indication for laparoscopy is the child on chemotherapy with an acute abdomen. There is generally a great reluctance to perform exploratory laparotomy on these children who are generally neutropenic and have associated clotting disorders, as laparotomy is associated with significant morbidity of wound dehiscence and bleeding. We have found laparoscopy a most useful diagnostic tool, and contrary to most beliefs, the presence of a coagulation disorder is not a contra-indication.

Other diagnostic procedures.—It's role in chronic inflammatory bowel disease is being evaluated at our institution. While Crohn's Disease is usually diagnosed on colonoscopic biopsies, we have used laparoscopy to successfully diagnose Crohn's in patients where the Gastroscopy and Colonoscopy have not been conclusive. We believe that it will have a useful place in the management of Chronic Inflammatory bowel disease.

Other laparoscopic procedures

Cholecystectomy.—Cholelithiasis is a relatively uncommon condition in children, but nonetheless, is one of those conditions which is now also universally done laparoscopically, and there is no longer any argument that this is the procedure of choice.

Appendicectomy.—Like many other institutions, laparoscopic appendicectomy is the commonest procedure performed in our institution. Most patients can be discharged within 24 hours after a routine laparoscopic appendicectomy, but the experience in our institution is that there is not much difference in the length of hospitalization for children with severe appendicitis, as these patients usually require post operative intravenous antibiotics for treatment of the intra-abdominal sepsis.

Although the advantage of appendicectomy is not a clear cut in terms of reduction of hospital stay, there is no doubt that return to normal activity is quicker following a laparoscopic appendicectomy.

Fundoplication.—Laparoscopic fundoplication is being reported in children with increasing frequency, and although large series are not yet available, it would appear that this operation has merit in the management of gastro-oesophageal reflux.

Laparoscopic pyloromyotomy.—We have now performed 45 laparoscopic pyloromyotomies in our institution without conversion to open operation or failures. We have not seen mucosal perforation in our series, but other authors have reported difficulties with this procedure with unrecognised mucosal perforations and conversions to open pyloromyotomy.

Although this is a technically easy laparoscopic procedure to perform, attention to detail is required to achieve low morbidity. Our results with laparoscopic pyloromyotomy is at least as good as conventional open Pyloromyotomy, and we will continue to perform this procedure as one of choice.

Laparoscopic nephrectomy.—We have now performed fifteen laparoscopic nephrectomies including 4 partial nephrectomies for duplex systems. There has not been any conversion to open nephrectomy, and no laparoscopic related complications. One patient with a non functioning kidney impacted with calculi developed post operative sepsis, and one patient had intra-operative bleeding from a renal vessel injury which was controlled laparoscopically, but all children have done well.

Our laparoscopic nephrectomies have all been performed via the intraperitoneal route. Unlike the experience of Clayman on others, we have not found it technically possible to use the retroperitoneal approach due to the lack of space between the 12th Rib and Iliac Crest for instrument trocars.

Discussion and conclusions

It is still too early to draw conclusions about the relative merit or otherwise of laparoscopic versus open operations.

The question that needs to be asked is whether it necessary for the results of laparoscopic procedures to be better than open operation? The important consideration surely is that it has to be safe. If it can be proven that any one laparoscopic procedure is as safe as its open counterpart, is this not sufficient reason to offer the benefits of a minimally invasive procedure to your patients? The benefits of minimal pain, minimal disfigurement and permanent cosmetic defect may be of secondary importance to Surgeons, but is of primary concern to our patients.

Like in adult surgical practice, Laparoscopic surgery is here to stay.

Riassunto

La laparoscopia nell'ambito della chirurgia pediatrica non è una procedura nuova anche se solo negli ultimi anni ha avuto una evoluzione tale da divenire una tecnica routinaria.

Sebbene Semm negli anni 70 sia stato il primo chirurgo ad effettuare la laparoscopia operativa, eseguendo le appendicectomie, le isterectomie e la legatura delle tube secondo modalità tecniche mini-invasive, è solo grazie a Mouret che la chirurgia laparoscopica è divenuta una metodica standard per alcune applicazioni della chirurgia generale.

I chirurghi pediatri, grazie all'esperienza maturata nel paziente adulto, hanno potuto confrontare e sperimentare le caratteristiche peculiari di questa nuova chirurgia nei piccoli pazienti.

I principali problemi incontrati sono legati a vari parametri: le differenze anatomiche quali le caratteristiche della regione ombelicale del neonato, il legamento falciforme, l'ipertrofia dei segmenti sinistri del fegato, le dimensioni della cavità addomi-

nale, etc. sono alcuni aspetti che rendono l'accesso mini-invasivo nel bambino non completamente paragonabile al paziente adulto.

Vi sono anche differenti risposte funzionali; il respiro prevalentemente addominale e la risposta particolarmente accentuata all'ipotermia hanno fatto si che le procedure, proprie della chirurgia generale dell'adulto, venissero personalizzate, soprattutto nel neonato e nei pazienti con età inferiore ai due, tre anni di vita.

Generalmente, i chirurghi pediatri, in questi anni, hanno dimostrato un limitato interesse verso questa nuova metodica soprattutto per i rischi ad essa legati e per il concetto, non sempre corretto, che quasi tutti gli interventi pediatrici sono di persè minimamente invasivi. L'introduzione dell'ago di Veress è sempre stato uno scoglio che ha reso questa procedura non scevra di rischi, se non eseguita in mani esperte. Un altro problema era la dimensione degli strumenti creati per il paziente adulto e che solo da uno o due anni sono stati personalizzati per il piccolo paziente.

Tuttavia, in alcuni centri, l'ampliamento dell'esperienza tecnica ha dimostrato una notevole utilità della chirurgia video-assistita, soprattutto per la diagnostica del testicolo non palpabile e per la stadiazione dei tumori, inoltre, per le procedure operative quali la colecistectomia, la Nissen, la piloroplastica e la nefrectomia ha dimostrato la sua importanza offrendo numerosi vantaggi.

È troppo presto per poter portare dei risultati e delle conclusioni definitive. Ancora, per ciascun intervento, ci domandiamo quale sia il miglior approccio in quanto siamo solo all'inizio di una esperienza che non può permettersi errori. Inoltre bisogna sempre tener presente che il piccolo paziente non è un adulto in miniatura ma è un entità particolare con caratteristiche anatomiche e risposte fisiologiche differenti e quindi non prevedibili solo applicando le esperienze maturate sul paziente adulto.

Parole chiave: Chirurgia laparoscopica - Chirurgia pediatrica.

References

1. Gans SL, Berci G. Peritoneoscopy in infants and children. J Pediatr Surg 1973;8:399-405.
2. Dubois F, Berthelots G, Levard H.Cholecystectomy par coelioscopie. Presse Med 1989;18:980-9.
3. Duckett JW. Editorial: Pediatric laparoscopy: Prudence please. J Urol 1994;151:742.
4. Bloom DA. Two-step orchiopexy with pelviscopic clip ligation of the spermatic vessels. J Urol 1991; 145:1030-3.
5. Cortesi N, Ferrari P, Zambarda E *et al.* Diagnosis of bilateral abdominal cryptorchidism by laparoscopy. Endoscopy 1976:8:33-4.
6. Holcomb GW Jr. Routine bilateral inguinal hernia repair. Am J Dis Child 1965;109:114-20.
7. Gilbert M, Clatworthy HW. Bilateral operations for inguinal hernia and hydrocele in infancy and childhood. Am J Surg 1959:97:255-9.
8. Stafford PW: The evaluation of chronic abdominal pain in children - a role for diagnostic laparoscopy? Abstract. 3rd International Congress on Endoscopy and Laparoscopy in Children. Munster, Germany, February 1-2, 1994.
9. Schier F. Waldschmidt J. Laparoscopy in children with ill-defined abdominal pain. Surg Endosc 1994:8:97-9.
10. Holcomb GW III. Laparoscopic cholecystectomy. Pediatric Endoscopic Surgery. Holcomb GW III, ed., Appleton and Lange, 1993;4:29-40.
11. Moir CR. Donohue JH. VanHeerden JA: Laparoscopic cholecystectomy in children: Initial experience and recommendations. J Pediatr Surg 1992;27:1066-70.
12. Leape LL. Ramenosky ML. Laparoscopy for questionable appendicitis. Can it reduce the negative appendectomy rate? Ann Surg 1980;191:410-3.
13. Semm K. Endoscopic appendectomy. Endoscopy 1983;15:50-64.
14. Valla JS. Limonne B. Valla V et al. Laparoscopic appendectomy in children: Report of 465 cases. Surg Laparosc Endosc 1991:1:166-172.
15. Schropp KP, Lobe TE. Laparoscopic appendectomy. Pediatric Endoscopic Surgery. Holcomb GW III, ed., Appleton and Lange 1993;3:21-8.
16. Lobe TE. Presbury GJ. Smith BM *et al.* Laparoscopic splenectomy. Pediatr Ann 1993:22:671-7.
17. Lobe TE. Schropp KP. Lunsford K. Laparoscopic Nissen fundoplication in childhood. J Pediatr Surg 1993;28:358-61.
18. Georgeson KE. Laparoscopic gastrostomy and fundoplication. Pediatr Ann 1993;22:675-7.
19. Tulman S. Holcomb GW III, Karamanoukian HL, et al: Pediatric laparoscopic splenectomy. J Pediatr Surg 1993:28:689-92.
20. Lobe TE. Schropp KP. Joyner RE *et al.* The suitability of automatic tissue morcellation for the endoscopic removal of large specimens in pediatric surgery. J Pediatr Surg 1994:29:232-4.
21. Georgeson KE. Laparoscopic Soave procedure in infants. Presented. SAGES, 1994.
22. Waldschmidt J, Schier F: Laparoscopical surgery in neonates and infants. Eur J Pediatr Surg 1991;1:145-50.
23. Alain JL. Laparoscopic treatment of pyloric stenosis. Presented at the Symposium on Endoscopic Surgery in Children, Berlin, December 1992.
24. Tan HL: Laparoscopic pyloromyotomy versus open operation -which is better? Abstract. 3rd International Congress on Endoscopy and Laparoscopy in Children. Munster, Germany, February 1-2, 1994.
25. Estes JM, MacGillivray TE, Hedrick MH *et al.* Fetoscopic surgery for the treatment of congenital anomalies. J Pediatr Surg 1992;27:950-4.

From

Paediatric Surgery

Edited by John D. Atwell

Published by Arnold

1998

ISBN 0 340 58608 7

CHAPTER 83

Paediatric laparoscopic surgery

H.L. TAN

Introduction

Laparoscopy in paediatric surgery is not new. In 1970 Drs Stephen Gans and George Berci evaluated endoscopy in children with the development of the Hopkins rod lenses and found it to be useful for diagnosis and simple procedures such as tissue biopsies. However, that year also saw the introduction by EMI of the computerized tomography (CT) scanner. This, together with the development of ultrasound imaging, and later magnetic resonance imaging (MRI), made it possible to diagnose intra-coelomic pathology by non-invasive means, hence laparoscopy did not find a useful role except in the diagnosis of intra-abdominal testes until relatively recently.

The parallel development of technology such as the development of extremely bright light sources, for example xenon or metal halide lamps, high-resolution video monitors and miniature charged coupled device (CCD) video cameras allowed a miniature high-resolution camera to be attached to the eyepiece which could be now be held by an assistant to transmit very high-quality endoscopic images onto a video monitor. This advance led to endoscopic performance of complex operative procedures.

Kurt Semm from Keil was the first to describe complex laparoscopic procedures such as appendicectomy and hysterectomy. Dr Phillip Mouret led the revolution in adult general surgery when he described laparoscopic cholecystectomy in 1987. Laparoscopic cholecystectomy was subsequently popularized by Drs Dubois, Perissat, Olsen and Reddick and although there was initial resistance and concern, it has become universally accepted today by 'adult' general surgeons as the treatment of choice for cholelithiasis.

Paediatric surgeons were more reluctant to embrace laparoscopic surgery until relatively recently and for very good reasons. The use of a blind Veress needle for insufflation is potentially hazardous, especially in infants. The incidence of complications from the use of Veress needle in children has been reported at between 3% and 10%, which is unacceptably high. However, the adoption of the open laparoscopy or Hasson technique for the introduction of the cannula has virtually eliminated the risk of inadvertent visceral injuries, and has made laparoscopy in infants much safer bringing about greater acceptance of laparoscopic surgery.

The size of the laparoscopic instrumentation has also been a problem. Adult laparoscopic instruments are generally too long for infants and this with the fact that many instruments required 10 mm diameter instrument cannulae meant that they were largely unsuitable for use in small infants. It is senseless to make several 10 mm incisions for laparoscopy in infants when many paediatric procedures are performed through incisions that are often not much more than 2–3 cm long.

These problems have since been resolved by the availability of shorter paediatric laparoscopic instruments and appropriately smaller diameter trocars. The recent introduction of the microlaparoscopy, with instrument diameters of 2–3 mm will see further adaptation of this to paediatric laparoscopic surgery, as these newer instruments can even be introduced through intravenous cannulae, further minimizing the trauma of surgical access.

Although paediatric laparoscopic surgery is safe, there are significant anatomical and physiological differences which have to be taken into account when attempting laparoscopy in children.

Anatomical differences

THE UMBILICUS

In a neonate, the two umbilical arteries (lateral umbilical ligaments) and the umbilical vein (ligamentum teres) are not obliterated for several weeks and there is a potential risk of gas embolism if CO_2 is insufflated into one of these patent vessels by a blind puncture technique. This is attached to the umbilical cicatrix in an infant. Owing to these anatomical features, it is generally wiser to establish the primary trocar in the supraumbilical region in infants. In older children, this difference is less obvious.

THE BLADDER

The neonate bladder is an intra-abdominal organ. This presents special problems, as the bladder is more liable to inadvertent perforation in infants. The peritoneum is also lax in the lower abdomen, allowing the parietal peritoneum to tent away from the advancing trocar, making the introduction of suprapubic and lower abdominal trocars difficult.

The inferior epigastric arteries are especially prominent in young children and is the most common vessel injury reported in both paediatric and adult laparoscopy. Care must be taken to avoid damaging this vessel.

THE UPPER ABDOMEN

The falciform ligament and the umbilical vein (ligamentum teres) form a very prominent fold in infants and children. It is easy to become 'lost' within this fold, when performing a Hasson open laparoscopy using a midline incision in the linea alba. It is therefore easier to make a transverse incision in the linea alba to gain entry into the abdominal cavity.

THE VISCERA

The neonatal and infant liver lies below the costal margin and reaches the umbilicus in neonates. The inferior vena cava and aorta are barely 1 cm away from the anterior abdominal wall and can be at substantial risk from perforation by blind trocars techniques even with the so-called safety shielded trocars. It is therefore recommended that all instrument trocars be introduced by direct internal video inspection to avoid visceral damage.

Physiological differences

RESPIRATION

Infant breathing is predominantly diaphragmatic and the increased intra-abdominal pressure from insufflation will splint the diaphragm leading to increased ventilatory requirements. This can be witnessed as an immediate rise in end tidal CO_2 of about 10 mmHg when the abdomen has been insufflated. This is correctable by the anaesthetist but becomes increasingly difficult if the intra-abdominal pressure is high. It is best to use no more than 10 mmHg pressure for abdominal insufflation in infants below 10 kg, higher pressures can be used with relative safety in children over this weight. Lower insufflation pressures in the infant will result in less splinting of the diaphragm, but under 10 mmHg the introduction of secondary trocars and cannulae becomes extremely difficult and hazardous.

HYPOTHERMIA

There is a substantial risk of children developing hypothermia when undergoing laparoscopic surgery. Maintaining the pneumoperitoneum by using high flow insufflation in particular, is fraught with hazard as the insufflated CO_2 is cold, and substantial heat loss can occur. The answer is to minimize gas leakage by using the smallest diameter cannulae possible and ensuring that all cannulae and instruments have adequate and sound gas seals.

There is an additional safety concern with high flow insufflators as most manufacturers have a default setting of 1 litre of CO_2/min, and do not allow insufflation at less than this rate. Given that a neonatal abdomen can only hold 500 ml of CO_2 when fully inflated, using high flow insufflation can cause the abdomen to distend too rapidly, and possibly result in arrythymias.

Notwithstanding all these potential limitations, many advances have now been made in paediatric laparoscopic surgery, and sufficient experience has been gained to establish an increasing role for laparoscopic surgery in paediatric surgery.

Laparoscopic trocar techniques

THE HASSON TECHNIQUE

Open laparoscopy or the Hasson method for the introduction of the primary trocar is safe and does not take any more time than using a blind Veress needle. While it is accepted that there are many variations in the technique, the technique used by the author will be described as it has been shown to be quick, easy and safe.

A full thickness supraumbilical semicircumferential incision is made in the skinfold down to the level of the linea alba. The plane between the subcutaneous fat and linea alba should be developed sufficiently to allow two pairs of haemostats or Kocher's forceps to be placed on the linea alba to lift the linea alba into the wound. A transverse incision is then made in the linea alba between the two instruments, whereupon the underlying round ligament in an infant or the translucent parietal peritoneum will drop away from the linea alba. The peritoneum is then held between two mosquito haemostats and a small incision made to gain access into the abdominal cavity. It should be immediately obvious that you are in the abdominal cavity as lifting the linea alba allows room air to fill the abdominal cavity, and you should immediately recognize normal viscera, usually omentum, underneath. If you are not sure, then in all probability you are still extraperitoneal.

In a small infant, it is easiest to hook the umbilical vein through the linea alba drawing the peritoneum with it. The peritoneum is then opened beside the falciform ligament, gaining access into the abdomen. A purse string should be placed in the linea alba *before* inserting in the primary trocar. This purse string is then tightened around the trocar with a single throw to stabilize the trocar and thus prevent gas leakage. The same suture can be used to close the defect by tightening the purse string at completion of the laparoscopic procedure. We have not to date witnessed any trocar injuries in any patient using this method.

SECONDARY TROCAR PLACEMENT

While it is easiest to introduce instrument trocars in older children by a direct puncture technique, in children we recommend that a small full-thickness skin incision be made which is wide enough to accommodate the cannula as this is the most difficult layer to penetrate. In neonates and infants, this incision is extended as a full thickness stab with a 11 scalpel blade under direct vision, and the stab is then widened sufficiently by spreading a pair of straight mosquito forceps along the tract so that a blunt trocar can be introduced in an atraumatic manner.

The ergonomics of laparoscopic surgery

Unlike conventional surgery, laparoscopic surgery is not intuitive. The general principles so often used to plan patient positioning, exposure and the floor plan (position of the surgeon, assistant and scrub nurse) in open surgery, if applied to laparoscopic surgery may be completely inappropriate. Many factors which are not considered important such as gravitational effects on internal organs can play an important role in the planning of laparoscopic surgery and are critical to the success or otherwise of laparoscopic surgery.

EYE–HAND CO-ORDINATION AND PARADOXICAL MOVEMENT

Laparoscopic instruments have to be inserted through an instrument port and work around a fulcrum. Hence instruments moved in one direction by the surgeon will be seen to move in the opposite direction both horizontally *and* vertically. This is first-order paradoxical movement and one can get used to this in a few minutes, as it is no different from rowing a boat. This however only applies in the situation where the endocamera is pointing straight ahead, and the video monitor is placed *directly in front of the surgeon.*

If on the other hand, the endocamera is pointing towards to surgeon, a left to right movement by the surgeon will also be seen as a left to right movement on the video monitor, that is the sideways movements is *not* paradoxical and yet the vertical movement continues to be. In other words, the horizontal axis is now reversed, and a second degree of paradox is introduced, and much like driving using the rear view mirror, many simple tasks then become much more difficult and sometimes impossible if this second-order paradox is introduced into laparoscopic surgery.

This problem of displaced visual co-ordination has been studied by Kohler in 1939 where he and other experimental subjects wore reversing prisms on spectacles for long periods of time. They reported 'days or weeks were spent in correcting movements disturbed by the reversal, some of which were incorrectly repeated hundreds of times'. In cases where left and right were reversed, someone trying to walk along a straight path would lurch from side to side like a drunk.

Most surgeons in fact intuitively recognize this and place themselves in an optimum position, so that they are correctly aligned with the camera and video. This however, is not the case with surgical assistants as it is commonplace to witness the assistant or theatre nurse on the other side facing the surgeon, working from a second video monitor. The assistant is now forced to work with second-order paradoxical movement and the only way he or she can control the instruments is by deliberately thinking about the movements each time, this is a potentially dangerous particularly if quick or fine movements are required, for example in controlling bleeding or endosuturing. It is impossible to suture let alone cut a suture in this position.

Ergonomic rule:
Surgeon assistant and scrub nurse must be on the same side.
The video monitor must be straight ahead, and camera pointing towards the monitor.
Do not use more than one video monitor.

The natural instinct is for surgeons to place instrument and cannulae as close to the operative field as possible, but this is impractical in laparoscopic surgery, as placing instrument and telescopic ports too close to the operative field will only restrict the ability to manipulate instruments around the fulcrum. As a general rule it is best to place trocars and cannulae about half the working length of your telescope and instruments away from the operative field.

There is much more to the ergonomics of laparoscopic surgery which cannot be effectively covered in this general chapter, but this gives an indication on the differences between open surgery and laparoscopic surgery.

Operative laparoscopy

DIAGNOSTIC LAPAROSCOPY

Contrary to expectations, diagnostic laparoscopy is not performed as often as one would expect. The availability of CT scanning, ultrasound and MRI has permitted an accurate and non-invasive means of delineating intracoelomic pathology, so that there is rarely a need to perform laparoscopy. It has been useful in three areas, namely for impalpable testes, in childhood malignancies and for the diagnosis of chronic inflammatory bowel disease.

LAPAROSCOPY FOR UNDESCENDED TESTES

Although undescended testes remain one of the most common paediatric surgical conditions, the majority of undescended testes are in the superficial inguinal pouch or within the inguinal canal, and only 1–3% of undescended testes are truly intra-abdominal and require laparoscopy. Laparoscopy is only indicated rarely and only in the patient in whom neither the cord nor the testis can be felt in the inguinal canal. If either of these structures can be felt, one should proceed to conventional inguinal exploration to bring an emergent testis down or to remove an atrophic testis.

Technique

The patient is positioned close to the foot of the table with a video monitor placed in the midline between the assistant and the surgeon. The patient should be positioned head down and the bladder emptied immediately prior to surgery. The surgeon should stand on the contralateral side to the testis being explored.

A 5 mm Hasson cannula is inserted by the method already described, and general laparoscopy performed. It is necessary to insert two 5 mm instrument ports, one in the contralateral iliac fossa, and the other on the ipsilateral side in the same line as the internal ring but above the umbilicus, as this will facilitate instrumentation. The internal inguinal ring is easily identifiable by following the external iliac vessels to where it meets the inferior epigastric vessels.

If an indirect hernia is present, the telescope is advanced into the inguinal canal and a testis if present, will be easily seen. If there is no hernia sac, it may be possible to identify the gubernaculum and, then follow it proximally to the intra-abdominal testis which is sometimes hidden behind the caecum or the sigmoid colon.

Another alternative is to locate the vas deferens behind the bladder and follow it either to its blind ending, or to the testis.

An atrophic testis can be easily removed using the 'Tan' bipolar forceps, specially designed to coagulate and cut at the same time.

If a testis is found in close proximity to a sac, try to relocate the testis into the inguinal canal. If you can easily do this laparoscopically, then convert to conventional orchidopexy, as it should be possible to bring this emergent testis into the scrotum. If on the other hand, the testis is truly well away from the internal ring, then one should attempt a staged Fowler–Stephens procedure. There are many ways to divide the internal spermatic vessels including the use of titanium clips, and the use of extra or intracorporeal suturing. In reality, it is just as easy and considerably less expensive to coagulate the vessels with the 'Tan' bipolar forceps, dividing the vessels in the process.

A second-look laparoscopy should be performed 6 months later and orchidopexy performed entirely laparoscopically by mobilizing the testis with its vas and vessels on a cuff of peritoneum. The inguinal canal will be absent in this instance, but one can be created by pushing a laparoscopic dissector from the internal ring lateral to the inferior epigastric vessels, into the scrotum where a sub-dartos pouch is created. A straight haemostat is then introduced up this tract created to grab the intra-abdominal testis to bring it into the scrotum.

LAPAROSCOPY IN CHILDHOOD MALIGNANCY

This may yet prove to be an important indication for diagnostic and therapeutic laparoscopy. While percutaneous needle biopsies have been useful for histological diagnosis of childhood malignancies, the need for larger tissue samples for cell culture has led to the increasing use of laparoscopic sampling of nodes and malignant tissue.

It is possible to obtain a large sample of neuroblastoma tissue for *n-myc* oncogene studies, but bleeding can be extremely difficult to control unless one performs the biopsy through the mesentery of the bowel. This allows the mesenteric defect to be sutured over to tamponade any likely bleeding in the retroperitoneum.

We have also staged tumours laparoscopically and this is especially useful in pelvic sarcomas where it can be difficult to tell on conventional organ imaging if there is local spread. If pelvic radiotherapy is required, it is an easy exercise to perform bilateral oopheropexy by suturing the ovaries to the side wall of the abdominal wall.

One of the most useful indications for laparoscopy is the child on chemotherapy with an acute abdomen. There is generally a great reluctance to perform exploratory laparotomy on these children who are generally neutropenic, with associated clotting disorders and poor wound healing. Laparoscopy is a most useful diagnostic tool and, contrary to most beliefs, the presence of a coagulation disorder is not a contra-indication. We have performed appendicectomies in such children for appendicitis without peri-operative problems.

CHRONIC INFLAMMATORY BOWEL DISEASE

The role of laparoscopy in chronic inflammatory bowel disease is being evaluated. While Crohn's disease is usually diagnosed on colonoscopic biopsies, laparoscopy has been used to diagnose Crohn's disease in patients where the gastroscopy and colonoscopy have not been conclusive. It is easy to identify the typical features of Crohn's disease laparoscopically, and to document accurately the length of the lesion and whether there are skip lesions. Laparoscopy should have a useful place in the management of chronic inflammatory bowel disease.

Other laparoscopic procedures

CHOLECYSTECTOMY

Cholelithiasis is a relatively uncommon condition in children, but it is now accepted that laparoscopic cholecystectomy is the procedure of choice.

We have not found it necessary to perform intraoperative cholangiography if the patient has normal liver function and a normal preoperative ultrasound demonstrates non-dilated bile ducts.

APPENDICECTOMY

In many European institutions, laparoscopic appendicectomy has become the most common procedure performed in children. Most patients can be discharged within 24 hours of laparoscopic appendicectomy, except for when there is accompanying peritonitis, or if the appendix is perforated or associated with an appendix abscess.

Contrary to most beliefs, it is possible to perform a thorough debridement and lavage of the entire peritoneal cavity, pelvis and subphrenic spaces at a laparoscopic appendicectomy.

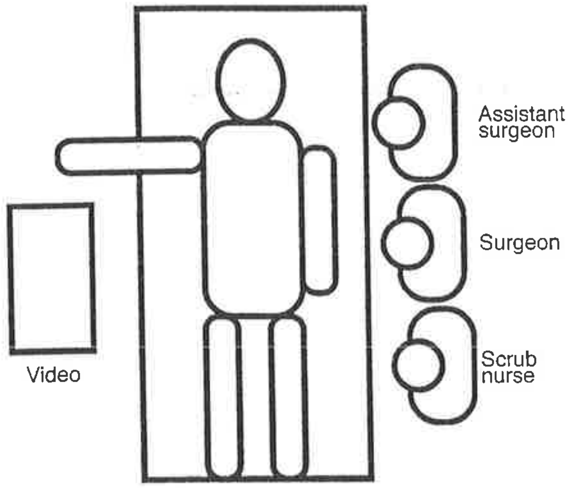


Fig. 83.1 Theatre layout of lap appendectomy.

Figure 83.1 illustrates a suitable theatre layout for an laparoscopic appendicectomy and Fig. 83.2 shows the port positions for this procedure. The stages of the laparoscopic appendicectomy are shown in Fig. 83.3.

The procedure is performed using one 10 mm umbilical Hasson trocar, and two other instrument ports, one in the midline in the suprapubic skin crease and the other in the right upper quadrant of the abdomen about 10 cm above the caecum.

There are many ways of controlling the mesoappendix including the use of an extracorporeal endoloop suture to ligate the mesoappendix *en masse*, and the use of titanium clips or Endo-GIA to divide the appendiceal artery, our method of choice is to skeletonize the appendix using the bipolar 'strip-tease' technique. While it is possible to use monopolar diathermy to control the mesoappendix, this is potentially hazardous in

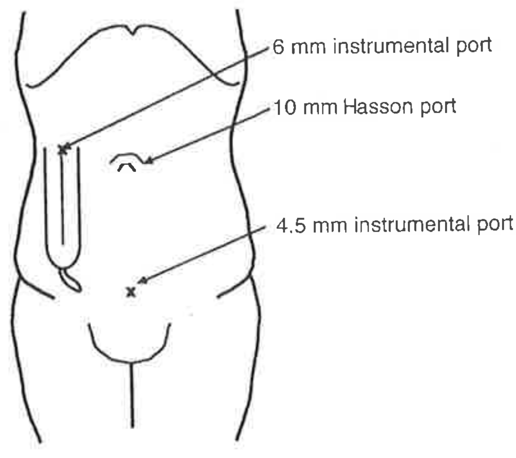


Fig. 83.2 Port positions for laparoscopic appendectomy.

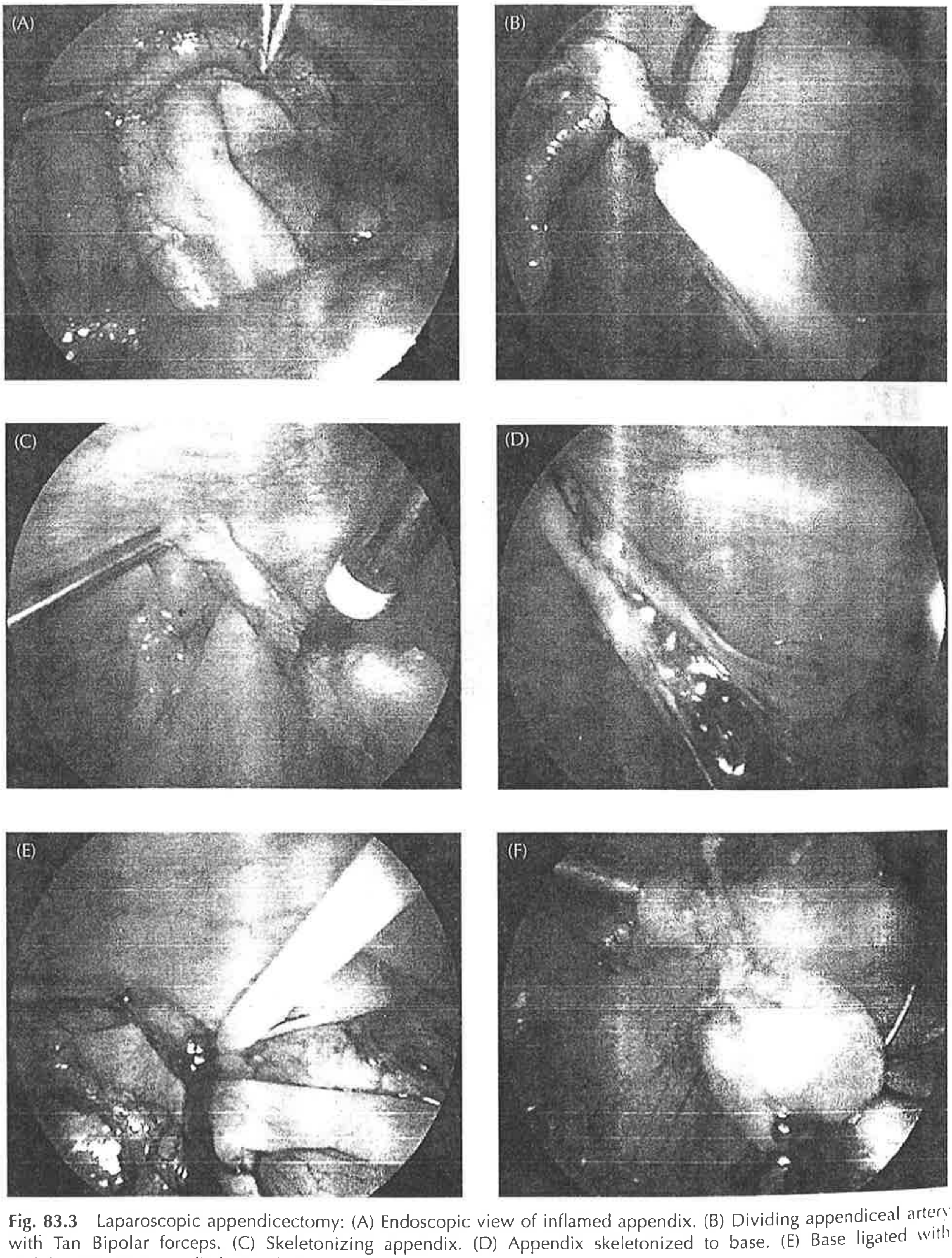


Fig. 83.3 Laparoscopic appendicectomy: (A) Endoscopic view of inflamed appendix. (B) Dividing appendiceal artery with Tan Bipolar forceps. (C) Skeletonizing appendix. (D) Appendix skeletonized to base. (E) Base ligated with Endoloop™. (F) Appendix being divided.

appendicectomy, as the return path for the current is through the base of the appendix, and caecal perforation has been reported using a monopolar technique. The stump of the appendix can be ligated with two endoloops, and there is generally no need to perform a purse-string suture to bury the stump.

FUNDOPLICATION

Laparoscopic fundoplication appears to be the most common laparoscopic procedure performed in North America, where the experience with gastro-oesophageal reflux appears to be different from the European counterparts, and successful laparoscopic fundoplication has been reported in infants as young as 4 weeks old.

This is not an operation to be performed by the novice laparoscopist as it requires dexterity and skills in intracorporeal suturing. There are also inherent dangers of breeching the mediastinal pleura when dissecting the crura resulting in a left tension pneumothorax, and there have been reported cases of injury to the aorta at laparoscopic fundoplication. In the hands of the skilled laparoscopic surgeon it is a relatively easy operation and may reduce operative morbidity.

We have not found it necessary to divide the short gastric vessels in performing laparoscopic fundoplication, and the left lobe of the liver can be retracted upwards away from the hiatus without a need to mobilize it.

LAPAROSCOPIC PYLOROMYOTOMY

Laparoscopic pyloromyotomy remained contentious for a while, as it appeared to make hard work of a relatively simple open operation. However it has now been demonstrated by many centres to be a safe procedure with minimal morbidity and is being increasingly accepted as the operation of choice for infantile hypertrophic pyloric stenosis. The results have been shown to be at least as good as conventional pyloromyotomy.

Technique

There are three ways to perform laparoscopic pyloromyotomy, these are Alain's, the author's and Rothenberg's but only the author's technique will be described.

Figure 83.4 illustrates a suitable theatre layout for laparoscopic pyloromyotomy and Fig. 83.5 shows the Ramstedt's port positions for this procedure. The stages of the laparoscopic pyloromyotomy are shown in Fig. 83.6.

The stomach must be emptied with an oro gastric tube. The patient is positioned at the foot of the operating table, and the surgeon sits at the end, with an assistant surgeon on the right of the surgeon. The video monitor is placed on the left-hand side of the operating table at the head end so that it is in the same visual line to facilitate eye–hand co-ordination. The patient should be tilted into about 15° head up position. This allows the transverse colon to fall away from the pylorus under gravity.

A direct viewing (0°) 4 mm telescope is inserted through an umbilical Hasson cannula using the technique already described. Under direct video-endoscopy, one 4 mm secondary port is inserted in the line of the nipple just below the costal margin on the left side. A second much smaller abdominal puncture is made on the right side to introduce the duodenal grabber. It is not necessary to insert an additional instrument port on the right because there is no interchange of instruments necessary on this side. Care must be taken not to damage the underlying liver when inserting the ports or interchanging instruments.

Two atraumatic graspers are inserted and the stomach and olive readily identified. It may be necessary to lift the falciform ligament with the right sided grasper to visualize the pylorus. The first part of the duodenum is stabilized just distal to the vein of Mayo by this instrument and is retracted inferiorly downwards and laterally, away from the overhanging neonatal liver,

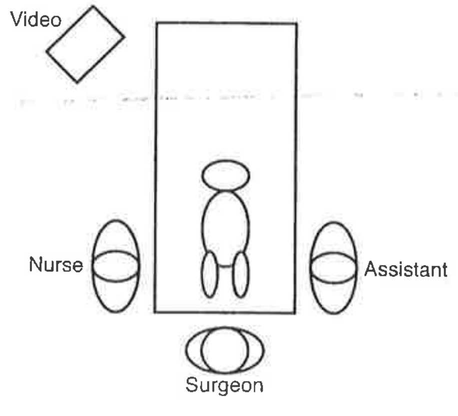


Fig. 83.4 Lap pyloromyotomy layout.

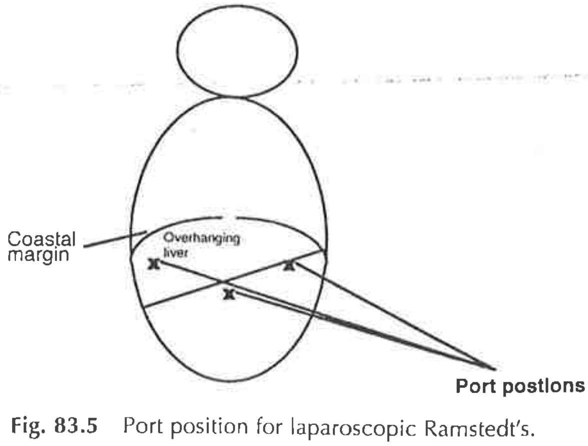


Fig. 83.5 Port position for laparoscopic Ramstedt's.

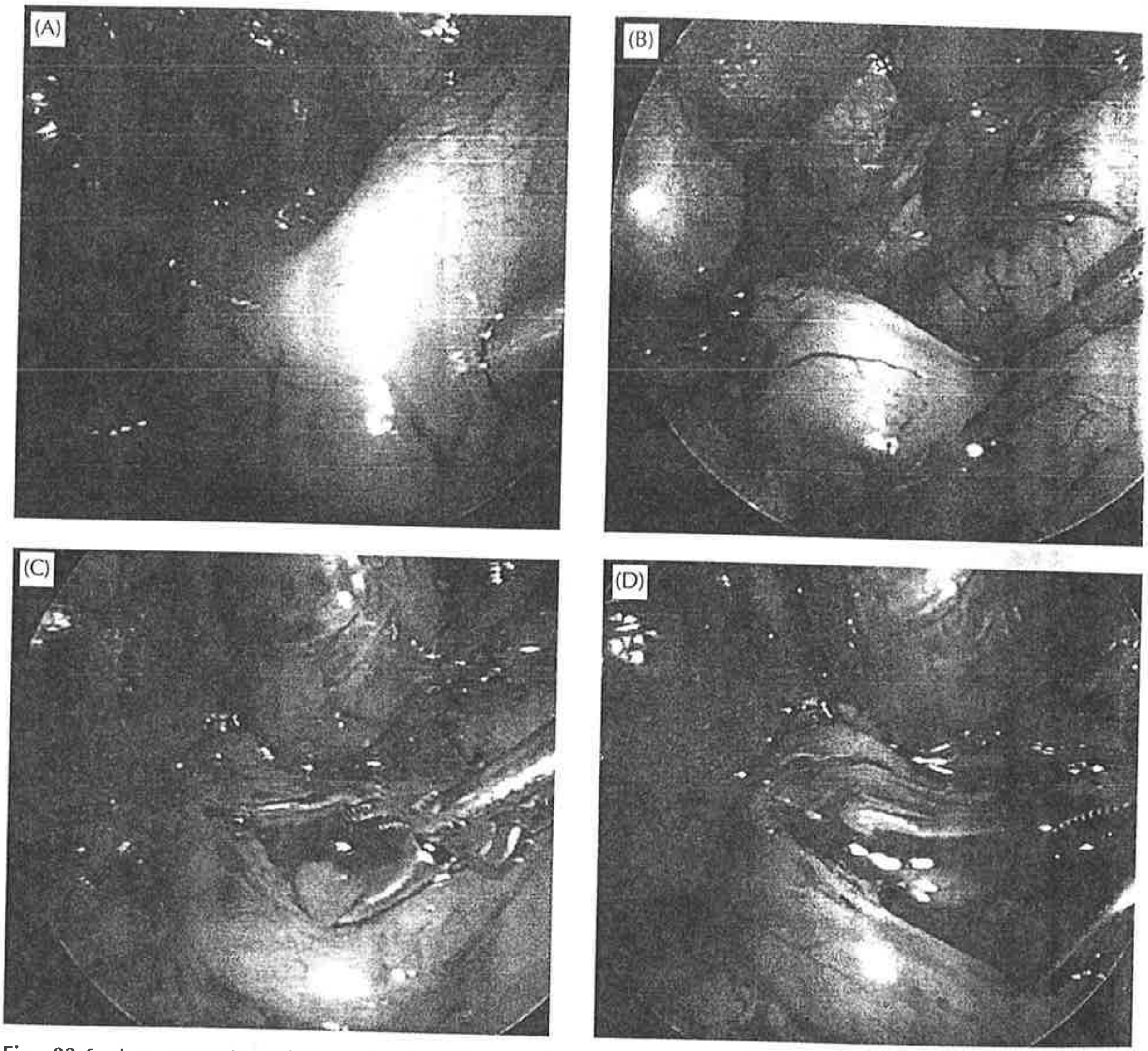


Fig. 83.6 Laparoscopic pyloromyotomy: (A) Typical endoscopic view of pyloric tumour. Note: duodenum stabilized by atraumatic grasper and antral limit of olivebeing 'palpated'. (B) Making deep incision in olive with 'Tan' endotome. (C) Spreading tumour. (D) Checking for mucosal perforation.

otherwise it will be difficult to perform the pyloromyotomy. This also serves to stabilize the pylorus.

The Tan endotome is then passed through the left-upper quadrant port, and a sero-muscular incision made, beginning at the duodenal end, cutting towards the antrum. This incision should be deep into the olive otherwise difficulty will be encountered with the spreader. There is no need to extend the incision beyond the olive.

The endotome is exchanged for the Tan pyloric spreader which should be thrust through the seromuscular incision until slight resistance of the intact mucosa is felt. The tumour is then spread by opening its jaws. The mucosa is inspected at this point in time. On completion of spreading, 30–50 ml of air is insufflated into the stomach by the anaesthetist, causing the mucosa to bulge, when it should be reinspected to exclude inadvertent perforation. It is not necessary to divide the last few fibres at the duodenal end, as this is the potential site for perforation.

The abdomen is then deflated, and steristrips are used to close the instrument ports except for the umbilical incision which is closed by tightening the purse string.

Although this is a technically easy laparoscopic procedure to perform taking less than 15 min to complete.

attention to detail is required to achieve low morbidity. We have now performed 70 laparoscopic pyloromyotomy using this technique without a single case of recurrence or mucosal perforation.

Minimally invasive paediatric urology

URINARY CALCULI

Interest in minimally invasive paediatric urology began with the evaluation of the role of extracorporeal shockwave lithotrypsy (ESWL) and percutaneous nephrolithotripsy (PCNL) for the management of urinary calculi. Unlike the experience with adults however, ESWL has been successful in treating only 26% of paediatric calculi in the author's series of 60 patients. This is a reflection of the aetiology of paediatric urinary calculi, as 40% of stones were infective, 23% were metabolic, and 12% had pre-existing renal tract abnormalities. These differences in aetiology makes ESWL unsuitable for the majority of stones in children, and as a result, we have relied on percutaneous or endoscopic means to manage our upper tract stones, and to retrieve broken or migrated double pig tailed stents, of which there were seven.

It has been demonstrated that percutaneous nephroscopy can be performed safely in children, the youngest to-date being a 16-week-old infant with an incomplete cystine staghorn. However there are special considerations in children that one has to address including the risks of hypothermia, the small size of the collecting system, and measures to minimize blood loss. We have developed a single staged dilator to perform safe PCNL in children. Most endourological procedures including PCNL can now be performed through a 14 or 16 Fr Amplatz operating sheath via a direct renal puncture technique. A 9.5 or 11 Fr operating cystoscope with an offset lens serves as an ideal infant nephroscope, as the 5 Fr operating channel will accommodate the small ultrasonic or lithoclast probe.

LAPAROSCOPIC NEPHRECTOMY/PARTIAL NEPHRECTOMY

The role of laparoscopic nephrectomy is still evolving. We have now performed 36 laparoscopic nephrectomies including 12 partial nephrectomies for duplex systems. There has not been any conversion to open nephrectomy, and no laparoscopic-related complications. One patient with a non-functioning kidney impacted with calculi developed postoperative sepsis, and two patients had intraoperative bleeding from renal vessel injuries which were controlled laparoscopically, but all children have done well.

It is now being reported that retroperitoneal nephrectomies are being performed but the author continues to perform nephrectomies via the transperitoneal route, as there is minimal mobilization of intraperitoneal structures, and the risk of adhesions after laparoscopic surgery has been shown to be minimal.

PUJ OBSTRUCTION

PUJ obstruction is the commonest obstructive uropathy in children. In spite of the various minimally invasive techniques available to treat PUJ obstruction, conventional open pyeloplasty until now, remains the gold standard with a success rate of over 90%.

Endopyelotomy has been used successfully in children, but the success of this technique in our series is only about 80%, which is similar to that achieved in adult series. Likewise, the published results of retrograde balloon dilatation in the author's series is inferior to that of open dismembered pyeloplasty.

Dismembered pyeloplasties remains the gold standard, but this remains a challenging operation to perform laparoscopically, as only very few attempts have been reported. However, the author has developed and refined the technique for laparoscopic transperitoneal dismembered pyeloplasty and a total of 16 pyeloplasties have now been performed by the author, the youngest being three months old. All uretero-pelvic anastomoses were completed by intracorporeal hand suturing. The refinements achieved has reduced the operating time from 160 min to less than 90 min for the last ten cases. This is the same as the time taken for conventional open surgery. Our preliminary results show that the success rate is 86%, fast approaching that of conventional open pyeloplasty.

VATS DECORTICATION

An increasing number of authors have reported successful thoracoscopic decortication of loculated empyema, and our results certainly show that there is considerable benefit to the child if a thoracotomy can be avoided.

Thoracoscopic decortication however, is a painstaking operation, as it can be extremely laborious to remove the peel from the lung and visceral pleura.

ADHESIOLYSIS

We have now managed 27 patients laparoscopically with suspected or established small bowel obstruction, with the need to convert to laparotomy in only one child. Diagnostic laparoscopy is an extremely useful tool in patients presenting with severe recurrent abdominal pains after open surgery, as it is possible to either exclude adhesion obstruction with certainty, or else deal with the adhesions entirely laparoscopically.

Acute and sub-acute small bowel obstruction can also be managed laparoscopically provided the abdomen is not too distended.

Conclusions

It is still too early to draw conclusions about the relative merit or otherwise of laparoscopic versus open operations. The question that needs to be asked is whether it is necessary for the results of laparoscopic procedures to be better than open operation? The important consideration is that it be safe. If it can be demonstrated that a laparoscopic procedure is as safe as its open counterpart and offers equivalent results then it is reasonable to offer the minimally invasive procedure as an alternative. This is still clearly an evolving and rapidly developing field.

Many of the problems encountered with laparoscopic surgery have been that it is a new technique, and unlike conventional surgery is not intuitive, requiring all surgeons to relearn new technical skills. However, with increasing experience and dexterity most surgeons are now finding it increasingly easier to perform laparoscopic procedures and in the same time as it would take them to perform a conventional open procedure. This leads to acceptance of the technique.

The benefits of pain reduction and decreased scarring are of primary concern to patients, therefore as in adult surgical practice, laparoscopic surgery offers a satisfactory alternative to open surgery in skilled hands.

Further reading

Alain, J.L., Grousseau, D. and Terrier, G. 1991: Extramucosal pyloromyotomy by laparoscopy. *Journal of Pèdiatric Surgery* **26**, 1191–2.

Dubois, F., Berthelots, G. and Levard, H. 1989: Cholecystectomy par coeliosoopie. *Presse Med* **18**, 980–9.

Dubois, F. and Card, P. 1990: Coelioscopic cholecystectomy: A preliminary report of 36 cases. *Annals of Surgery* **211**, 60–2.

Gans, S.L. and Berci, G. 1973: Peritoneoscopy in infants and children. *Journal of Pediatric Surgery* **6**, 399–405.

Gans, S.L. and Berci, G. 1971: Adyanoes in endoscopy of infants and children. *Journal of Pediatric Surgery* **6**, 199–233.

Kohler, I.: Quoted by Smith, K.U. and Smith, W.M. 1966: Perception and motion, in Vernon, M.D. (ed.) *Experiments in visual perception*. Penguin. Excerpted from Smith, K.U. and Smith, W.M.: *Perception and motion*. Philadelphia, PA: W.B. Saunders, 1962, Chapter 5.

Patkin, M. 1967: Ergonomic aspects of surgical dexterity. *Medical Journal of Australia* **2**, 775–7.

Perissat, J., Collet, D. and Belliard, R. 1990: Gallstones: laparoscopic treatment – cholecystectomy, cholecystostomy, and lithotripsy. *Surgery Endoscopy* **4**, 1–5.

Reddick, E.J. 1988: Laparoscopic laser cholecystectomy. *Clinical Laser Monthly* **6**(10), 400–1.

Reddick, E.J. and Olsen, D.O. 1989: Laparoscopic laser cholecystectomy: A comparison with minilap cholecystectomy. *Surgery Endoscopy* **3**, 181–3.

Rothenberg, S. 1997: Laparoscopic pyloromyotomy: the slice and pull technique. *Pediatric endosurgery and innovative techniques*, Vol. 1, No. 1. Mary Ann Liebert.

Semm, K. 1983: Endoscopic appendectomy. *Endoscopy* **15**, 50–64.

Tan, H.L. and Najmaldin, A. 1993: Laparoscopic pyloromyotomy for infantile hypertropic pyloric stenosis. *Pediatric Surgery International* **8**, 376–8.

Tan, H.L., Segawa, O. and Stein, J.E. 1995: Laparoscopic bipolar strip-tease appendicectomy. *Surgery Endoscopy* **9**, 1301–3.

Part Three

Developments in Paediatric Minimally Invasive Urology

Introduction to part three

The last section of the thesis concentrates on paediatric urology and finishes off with course material from laparoscopic workshops conducted by myself.

The first part of this section deals with the uretero-pelvic junction as this remains the main focus of my clinical interest.

Experience with endopyelotomy suggested that the gold standard for the management of uretero-pelvic junction in children remains dismembered pyeloplasty. Even though endopyelotomy continues to be an attractive alternative to open surgery in the adult population, the main problem with this technique is the need for the patient to wear an externalised nephrostomy stent for six weeks, something which is not well tolerated in children. The results were also not as good as open pyeloplasty.

By now, there were increasing reports of successful balloon angioplasty for coronary vessel disease, and the development of very small high pressure balloon dilators afforded a chance to evaluate if the same success could be achieved in the urinary tract as with coronary vessels.

We embarked on a novel idea to evaluate the possibility of dilating ureteric stricture. This culminated in the development the technique for retrograde balloon dilatation of uretero-pelvic junction obstructions in children, and publication of our initial results in Urology.

However, it was clear that the results of this technique are not as good as that achievable by dismembered pyeloplasty, and this remains the gold standard.

This section then discussed the failed laboratory attempts to produce a hydronephrotic kidney, and also discusses how the laparoscopic technique for dismembered pyeloplasty evolved in the laboratory nonetheless. This resulted in the evolution of a successful technique for laparoscopic dismembered pyeloplasty, and the publication of the first reported series of laparoscopic dismembered pyeloplasty in children.

The technique has remained essentially unchanged since it was originally described except that we are able to use finer suture material with better laparoscopic needle drivers becoming available.

We have been able to produce a reasonably large series of laparoscopic Anderson-Hynes dismembered pyeloplasty which was presented at the America Academy of Paediatrics meeting in San Francisco in 1998, and which is in print in the Journal of Urology.

There is included a collection of other papers on endoscopic urology which have also been published.

Concluding remarks are made regarding future developments and progress in paediatric endosurgery, and examines the training requirements for paediatric laparoscopic surgery. It addresses some of the problems peculiar to paediatrics, and also includes course material from various workshops I have conducted.

Relevant concluding remarks about the possibility of treating the majority of uretero-pelvic junction obstruction by non open methods are also made.

The Uretero-Pelvic Junction revisited

As a paediatric urologist at the Royal Children's Hospital in Melbourne, it is not surprising that the focus of my work should be uretero-pelvic junction obstruction, this being the commonest obstructive uropathy in childhood.

While conventional open Anderson-Hynes dismembered pyeloplasty offers very good results in relieving the obstruction, this is nonetheless a major operation often leaving a large unsightly upper abdominal scar. Being an upper abdominal incision, it is also accompanied by significant post operative pain and disability and lastly, the open operation is not without its morbidity as well.

The results of endopyelotomy in children first reported by us is good as that achieved in the adult series, but unfortunately is still inferior to the results achievable by conventional open operation. The need to leave an external nephrostomy stent for six weeks is an added disadvantage, as external nephrostomies are not well tolerated in children. Hence this lead me to consider other alternatives.

At the annual scientific meeting of the society for Minimally Invasive Therapy in 1991, I came across a percutaneous retrograde balloon dilator for balloon angioplasties which only measured 5 French at the Boston Scientific Corporation exhibition booth. On returning to Australia, I contacted the local agents N Stenning and company, and was able to obtain a supply of these catheters for clinical evaluation to see if uretero-pelvic junction obstructions could be dilated in a retrograde manner.

We were initially supplied with 5 French balloons, but were later supplied with a stock of 3.8 French balloons with a burst pressure of 8 atmospheres.

Informed consent was obtained from all patients on whom we were evaluating this new treatment. This technique involved performing a cystoscopy and a retrograde pyelogram and then passing a balloon dilator to straddle the uretero-pelvic junction to forcibly dilate it under image intensifier control. A double J stent for six weeks was then inserted and left in situ for six week to stent the dilated uretero-pelvic junction.

We reported success with this technique. However, although this is very minimally invasive, requiring only day surgical admission, the results are still inferior to conventional open pyeloplasty, the overall success rate for retrograde dilatation is only 70%. Hence, the Anderson-Hynes dismembered pyeloplasty remains the gold standard.

In spite of this, retrograde balloon dilatation of Uretero-pelvic junction obstruction is a technique which should be evaluated again, as most of the failures have been related to technical problems such as insufficient pressure generated by the balloons, problems which may be resolved with improved technology.

We are now working with manufacturers to produce a balloon catheter with a burst pressure of 22 atmospheres as opposed to the eighth atmosphere burst pressure in our initial series, and we will begin evaluating this in the new millennium.

RETROGRADE BALLOON DILATION OF URETEROPELVIC OBSTRUCTIONS IN INFANTS AND CHILDREN: EARLY RESULTS

HOCK L. TAN, F.R.A.C.S., JULIAN P. ROBERTS, F.R.C.S. (PAED),
AND D. GRATTAN-SMITH, F.R.A.C.R.

ABSTRACT—**Objectives.** Although balloon dilation is a successful and widely accepted minimally invasive method of treating vascular, esophageal, and colonic strictures, it has not been reported in the management of ureteropelvic junction (UPJ) obstruction in infants. We investigated the role of retrograde balloon dilation as the primary treatment of UPJ obstruction in infants, and we report the technique and early results.

Methods. Prospective study of infants and young children undergoing retrograde balloon dilation of primary UPJ obstruction using a 3.8 F, 8 atmosphere radial balloon dilator.

Results. Ten infants and children with a median age of 16 months (range, 3 months to 9 years 6 months) underwent retrograde balloon dilation for proven UPJ obstruction with successful outcome in 7 patients following one dilation.

Conclusions. The minimally invasive nature of this technique and our encouraging early results lead us to conclude that this technique warrants further clinical evaluation. UROLOGY® **46:** 89–91, 1995.

The accepted management of ureteropelvic junction (UPJ) obstruction has been open dismembered pyeloplasty. Although endopyelotomy has been reported to be successful in adults[1,2] and children,[3] there have been few reports of its use in infants. Both antegrade and retrograde balloon dilation have been successfully used in adults with ureteric strictures[4,5] and primary UPJ obstruction.[6] Successful retrograde dilation of primary UPJ obstruction has recently been described in a small group of children.[7] Despite these other options, open pyeloplasty is still the mainstay of treatment for UPJ obstruction in this age group. To help assess the place of balloon dilation of UPJ obstruction in infants and children, we report our technique and results in the first 10 patients treated at our institution.

MATERIAL AND METHODS

Between June 1992 and March 1994, 10 infants and children presented with UPJ obstruction suggested antenatally or postnatally by renal ultrasound. The diagnosis of obstruction was documented in all patients by Lasix renography and additionally by the Whitaker test in 6 children (Table I). Median age at dilation was 16 months (range, 3 months to 9 years 6 months). Informed consent was obtained from the parents to perform a retrograde balloon dilation of the UPJ.

From the Departments of Paediatric Surgery and Paediatric Radiology, The Royal Melbourne Children's Hospital, Flemington Road, Parkville, Victoria 3052 Australia

Hock L. Tan, M.D., Gleneagles Hospital, 6 Napier Road, #03-03, Singapore 1025

Submitted (Rapid Communication): January 6, 1995, accepted (with revisions): January 16, 1995

TECHNIQUE

A cystoscopy is performed, and a 0.032-inch Teflon-coated straight guide wire is introduced under image intensifier and passed into the pelvis to the kidney. The cystoscope is then withdrawn, and a 5 F ureteral dilator is introduced over the guide wire to dilate the ureterovesical junction. The dilator is exchanged for a 5 F purpose built catheter and a retrograde urogram is performed to outline the upper tracts.

The 0.032-inch guide wire is then exchanged for a 0.018-inch wire that is passed into the pelvis of the kidney. The 5 F catheter is removed and exchanged for a 3.8 F, 8 atmosphere Meditech (Boston Scientific Corp, Watertown, Mass) radial balloon dilator (Fig. 1). Under the image intensifier, the balloon is maneuvered to straddle the UPJ, which is dilated until the hourglass constriction is lost, or for a duration of 3 minutes (Fig. 2). The UPJ is then stented with a 4.8 F internal double pigtail catheter for 6 weeks. Perioperative and postoperative antibiotics are administered to all patients. Patients are discharged within 24 hours of the dilation, and the double pigtail stent is removed at 6 weeks as a day procedure.

Success of the procedures was assessed 3 to 6 months postoperatively by Lasix renography.

RESULTS

There were no operative complications from the dilations. Seven children were treated successfully, with a median follow-up period of 22 months (range, 4 to 25). In 6 there was no evidence of obstruction during Lasix renography performed at 3

TABLE I. *Patient details, preoperative and postoperative investigations*

Patient	Age at Operation (months)	Side	Presentation		Preoperative Whitaker	DTPA (Drainage Halftime Min)*	
			Antenatal	UTI		Preoperative	Postoperative
1	15	R	Y	. .	. .	31	5
2	14	L	Y	. .	Y	30	3
3	42	R	Y	. .	Y	90	28
4	66	R	. .	Y	Y	21	3
5	6	L	Y	. .	Y	82	10
6	6	L	. .	Y	Y	98	3
7	114	L	. .	Y	. .	78	19†
8	3	L	Y	. .	Y	103	100†
9	18	R	Y	. .	. .	58	ND†
10	89	R	. .	Y	. .	34	11

Key: DTPA = diethylenetriamine pentaacetic acid; L = left; ND = no data; R = right; UTI = urinary tract infection, Y = yes.
*Normal halftime clearance less than 15 minutes.
†Treated with dismemberment pyeloplasty.

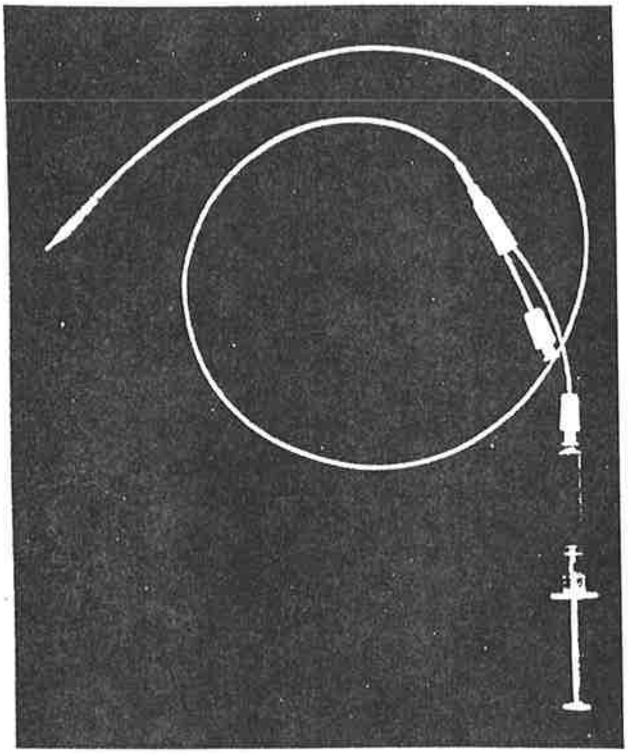


FIGURE 1. *A 3.8 F Meditech miniballoon dilator (Boston Scientific Corp, Watertown, Mass).*

to 6 months postoperatively. In the seventh patient, significant improvement in drainage time was recorded, with the Lasix washout halftime decreasing from 90 to 28 minutes (Table I).

Two children remained obstructed after dilation and underwent open pyeloplasty 4 and 6 months after dilation, without complications. In these patients the balloon dilation had not been considered technically successful due to inability to dilate the stricture completely in one and balloon disruption in the other. One patient (patient 9) had an open pyeloplasty because of stent migration into the renal pelvis, before postoperative diethylenetriamine pentaacetic acid (DTPA) drainage was established. The overall success rate of retrograde balloon dilation in our series is, therefore, 70%.

COMMENT

The management of UPJ obstruction in infants remains controversial, some authors advocating early relief of obstruction, others preferring observation to see if the pathologic condition resolves. Although we agree that most antenatally diagnosed hydronephrosis can be watched, there remains a small group of patients requiring treatment. In these infants, the treatment has always been open dismembered pyeloplasty, which is not without significant complications.[8] A minimally invasive method of relieving the obstruction would, therefore, be an attractive option. Doraiswamy[7] described balloon dilation of post-pyeloplasty strictures and congenital UPJ obstruction in children using Fogarty catheters. However, limitations of this type of catheter, designed for arterial dilation, dictated that the minimum age of a child undergoing balloon dilation in his series was 4 years. Technologic advances, such as the commercial introduction of 3.8 F balloon dilators, have facilitated balloon dilation in younger patients. Although the newborn ureterovesical junction will usually only accommodate a 3 F catheter, it does nonetheless dilate to 5 F with relative ease to allow the passage of larger catheters. The current range of miniballoon dilators, therefore, allows passage of a catheter across the UPJ to treat primary strictures even in infants.

Our technique also differs from that of Doraiswamy[7] by routinely utilizing double pigtail catheters postoperatively. We believe that these are important in preventing acute obstruction due to edema at the site of dilation in such small ureters. This complication was noted in 1 of 6

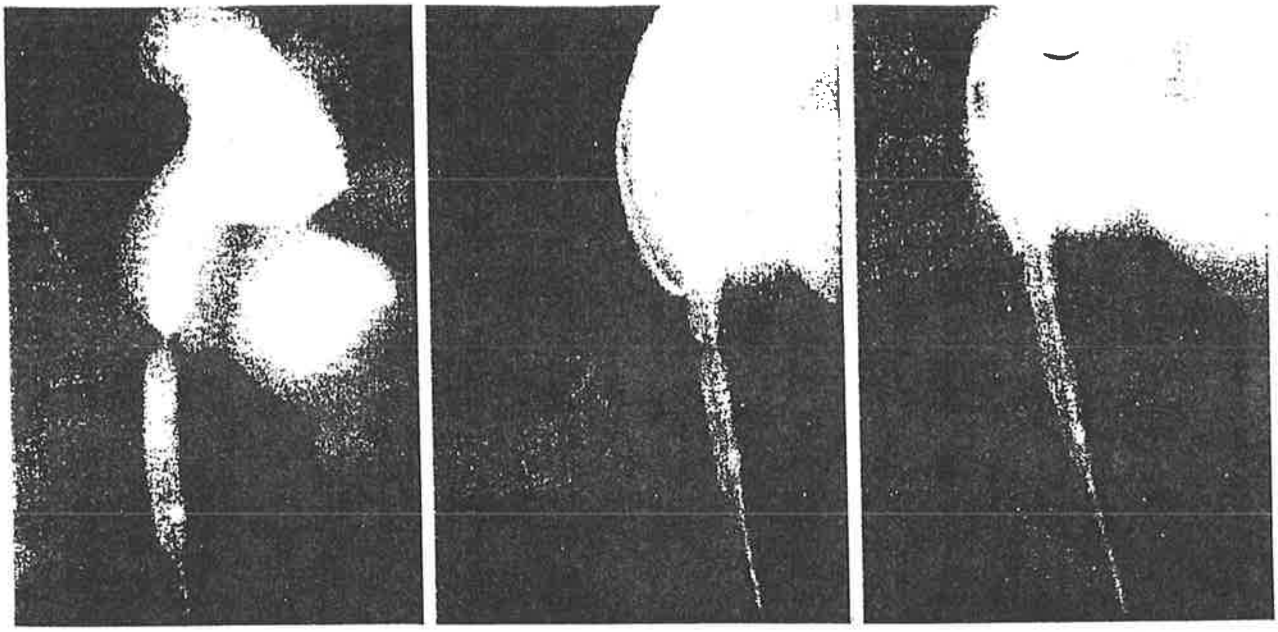


FIGURE 2. *Radiograph of retrograde balloon dilation of ureteropelvic junction (UPJ) obstruction. Note the dependent tight stricture typical of UPJ obstruction found in these patients.*

children with primary UPJ obstruction treated by Doraiswamy. Such stents also permit early discharge from the hospital.

We have not considered redilating strictures that show no improvement after the primary treatment and have proceeded with open pyeloplasty. Doraiswamy,[7] however, repeated dilations up to six times. We remain reluctant to dilate a stricture repeatedly because of the likelihood of recurrent failure or ureteric damage; but if recurrent obstruction occurs, repeated dilation appears to be a safe option. It is also important to note that unsuccessful attempts at dilation did not prejudice later open pyeloplasty in our 3 cases.

We have found the pathologic features to be the same in all cases treated: a large extrarenal pelvis with a dependent ureter and a very tight hourglass-like stricture that requires up to 12 atmospheres of pressure to dilate (Fig. 1). This appearance was confirmed in the 3 cases that later underwent open pyeloplasty. Unlike McClinton *et al.*[6] in adults, it has not been necessary to disrupt the UPJ completely in infants for success. This may be because the obstruction has a different etiology to that seen in adult patients. Complete disappearance of waisting is not necessary for a successful outcome, but in both cases where the dilation was not considered optimal, there was recurrence of obstruction despite stenting for 6 weeks.

ACKNOWLEDGMENT. To the Boston Scientific Corp and N. Stenning for providing material assistance for this project.

REFERENCES

1. Wickham JE, and Kellet MJ: Percutaneous pyelolysis. Eur Urol 9: 122–124, 1983.

2. Kuenkel M, and Korth K: Endopyelotomy. Long term follow up of 143 patients. J Endourol 4: 109–116, 1990.

3. Tan HL, Najmaldin A, and Webb DR: Endopyelotomy for pelvi-ureteric junction obstruction in children. Eur Urol 24: 84–88, 1993.

4. Finnerty DP, Trulock TS, Berkman W, and Walton KN: Transluminal balloon dilatation of ureteral strictures. J Urol 131: 1056–1060, 1984.

5. Netto NR Jr, Ferreira U, Lemos GC, and Claro JF: Endourological management of ureteral strictures. J Urol 144: 631–640, 1990.

6. McClinton S, Steyn JH, and Hussey JK: Retrograde balloon dilatation of pelviureteric junction obstruction. Br J Urol 71: 152–155, 1993.

7. Doraiswamy NV: Retrograde ureteroplasty using balloon dilatation in children with pelviureteric obstruction. J Pediatr Surg 29: 937–940, 1994.

8. Sheldon CA, Duckett JW, and Snyder HM: Evolution in the management of infant pyeloplasty. J Pediatr Surg 27: 501–505, 1992.

Dismembered Pyeloplasty

Having reported our experience with endopyelotomy and retrograde radial balloon dilatation in children, we concluded that open dismembered pyeloplasty remains the gold standard. As long as the results of either endopyelotomy or radial balloon dilatation are inferior to conventional open surgery, these would not be attractive alternatives to the management of UPJ obstruction in children.

It appears therefore that the best option is still dismembered pyeloplasty. However, reports of laparoscopic dismembered pyeloplasty are very few and far between. Furthermore, all reports in the literature are discouraging, some authors suggesting that this is an extremely difficult operation, taking 600 minutes to perform, far too long to ever become accepted as an alternative to open surgery.

By the time of these first reports, I had performed laparoscopic nephrectomies in piglets as well as in about 20 young children, and felt the time was right to evaluate the possibility of performing a dismembered pyeloplasty laparoscopically.

I returned to the animal lab in an attempt to create a partial Uretero – Pelvic junction obstruction in dog so that that I can return to perform a laparoscopic dismembered pyeloplasty later. By doing so, I hoped to develop an alternative technique, as it appeared that the published methods were tedious and difficult.

This proved to be impossible. Crushing the Uretero-Pelvic junction with haemostats, burning it with bi-polar or monopolar diathermy did not cause any stenoses to develop, the ureter being completely normal six weeks after delivering all kinds of insult to it.

The only successful animal model of a partial uretero-pelvic junction obstruction described is to bury the ureter in the psoas muscle. Clearly this technique is unsuitable for performing a laparoscopic pyeloplasty at some later stage because the ureter would be embedded within the muscle.

Instead of creating a partial obstruction, I decided to practice uretero-ureteric anastomoses in piglets. It is not possible to perform a uretero-pelvic re-anastomosis, as the renal pelvis in a piglet is completely intra-renal.

Even though I had developed sufficient skills to confidently perform intra-corporeal suturing, I learnt that trying to re-anastomose the ends of a small ureter with 5/0 or 6/0 monofilament suture material was diabolically difficult because of mobility of the ends that need to be brought together. I felt that it was necessary to stabilise the ends in the same way that vascular surgeons stabilise vessels when performing micro-anastomosis.

In devising various ways of stabilising the anastomosis, we found that the most effective was to pass a trans-abdominal suture to transfix one end. This "hitch stitch" became the cornerstone of the technique we subsequently developed for laparoscopic dismembered pyeloplasty.

Again the ergonomics of the operation and correct placement of instrument trocar positions were worked out in the laboratory setting before the operation was attempted clinically.

The first dismembered pyeloplasty was attempted in a 20 year old patient who had undergone two previous failed open pyeloplasty and was left with significant residual obstruction.

This attempt ended in dismal failure as the UPJ was completely embedded in tough fibrous tissue, and considerable difficulties were encountered in mobilising the uretero-pelvic junction. Even on conversion to open pyeloplasty, the uretero-pelvic junction was completely stuck to the retroperitoneum making for an exceedingly difficult open operation.

The second attempt was successful. This was on a patient who had a failed endopyelotomy. The parents were keen for me to attempt a laparoscopic procedure.

Instead of performing a classical Anderson-Hynes dismembered pyeloplasty however, I decided to perform a Y-V Foley type plasty, as I had concerns that I would not be able to re-anastomose the ureter to the pelvis!

Spurred by the success of this which took 150 minutes, I then attempted two more Y-V plasties before I had sufficient courage to perform a proper Anderson-Hynes dismembered pyeloplasty.

This has resulted in two papers on laparoscopic dismembered pyeloplasty, the first reporting our initial experience, which included the Y-V plasties. The second paper reports on the results of laparoscopic dismembered Anderson-Hynes pyeloplasty proper.

To date there are only two other reports of laparoscopic dismembered pyeloplasty in children, the first being a case report by Dr.Craig Peters at the Boston Children's hospital.

The second again, is a case report of two cases by Professor Felix Schier from Jena Germany. Felix was my invited faculty and watched me perform a laparoscopic pyeloplasty at an international paediatric laparoscopic workshop in Malaysia In 1995.

Our series of eighteen Anderson-Hynes dismembered pyeloplasty remains the largest published series in children to date. We have also reported the youngest patients (two three month old infants) undergoing laparoscopic pyeloplasty.

It is clear that an appreciation of correct ergonomics and the employment of the hitch stitch has reduced our operating time considerably, the average operating time being 90 minutes in our series.

Thus, we have been able to demonstrate that laparoscopic pyeloplasty can be performed in the same time as conventional open surgery. Furthermore, the results to date are superior to endopyelotomy or retrograde balloon dilatation, and is now approaching that of conventional open surgery.

There have also been vast improvements in the laparoscopic instrumentation available. The Szabo-Berci needle driver was employed in the first few cases, and even though we were able to suture using 5/0 PDS, these instruments are not designed for 5/0 or even finer suture material. The availability of the 3mm "Koh" needle driver in the past 18 months or so (I was fortunate to have one of the first pairs available for evaluation) has made a significant difference to the ease of suturing, as it is now possible to use 6/0 PDS to perform an accurate uretero-pelvic anastomosis.

It is probable that the technique of laparoscopic Anderson-Hynes dismembered pyeloplasty as developed by myself, will find increasing acceptance because it can now be performed in good time and with good results. Unquestionably, it remains a difficult operation to learn, with a steep learning curve.

However, the fact that Professor Felix Schier has performed two cases taking only relatively short times implies that the technique can be learnt by a competent laparoscopic surgeon adept at endosuturing.

At this point in time however, it does not appear to be suitable for very small infants as the only two failures in our series has been in three month old infants. Two patients in our series operated on at six months of age had satisfactory outcomes.

We therefore currently recommend that the operation should not be performed in a child less than six months old, hence, we are continuing to evaluate the possibility of using smaller and higher pressure retrograde balloons as the method of treating neonatal uretero-pelvic junction obstruction.

My current believe is that it is possible to manage almost all cases of uretero-pelvic junction obstruction in children without recourse to open surgery.

My current recommendation is to attempt a retrograde balloon dilatation in newborns and infants less than six months old, and to leave them with a double J stent for six months. The renal function should then be re-evaluated after removal of the stent and if the obstruction persists, then one should to laparoscopic dismembered pyeloplasty.

These recommendations form the basis of an invited paper being prepared for Dialogues in Pediatric Urology", but which is not included in this thesis, as the paper is not yet complete.

Laparoscopic dismembered pyeloplasty in children: preliminary results

H.L. TAN and J.P. ROBERTS*
*Gleneagles Hospital, Singapore and *Urology Unit, General Surgical Department, Royal Children's Hospital, Melbourne, Australia*

Objectives To investigate the technique of laparoscopic pyeloplasty in children with pelvi-ureteric junction (PUJ) obstruction.

Patients and methods Six children, aged between 2.5 and 15 years, were treated by laparoscopic pyeloplasty in a prospective study. The outcome was assessed by post-operative isotopic renography. Four of the children underwent a Y/V plasty of the PUJ structure and one a Hynes-Anderson dismembered pyeloplasty.

Results One case (the first in this series) was converted to open pyeloplasty due to adhesions around the PUJ from previous surgery. One patient developed an abdominal haematoma at the trocar site, which resolved without treatment. All anastomoses were completed without complication. Five of the children had normal or significantly improved drainage times on post-operative renography. In one patient, the drainage time deteriorated post-operatively, although differential function of the operated kidney improved.

Conclusions These early results suggest that laparoscopic pyeloplasty in children is feasible, safe and effective; a longer term follow-up is awaited.

Keywords Pelvi-ureteric junction obstruction, laparoscopic pyeloplasty

Introduction

Pelvi-ureteric junction (PUJ) obstruction is one of the commonest obstructive uropathies in children. Conventional open dismembered pyelopasty remains the 'gold standard' but there has been increasing acceptance of minimally invasive surgical alternatives, such as balloon retrograde dilatation and endopyelotomy [1,2]. Although encouraging results in the short term have been reported for both these techniques, none equal those from open pyelopasty. Laparoscopic pyeloplasty has been used in adults [3–5] and recently in a child [6]. We present our initial experience with the technique of laparoscopic pyeloplasty in a small group of children.

Patients and methods

Between October 1993 and December 1994, six children (median age 8.5 years, range 2.5–15) with PUJ obstruction were treated by laparoscopic pyeloplasty at the Royal Children's Hospital, Melbourne, Australia. All underwent pre-operative isotopic renography (using DTPA) and ultrasonography to confirm the diagnosis, and two patients also underwent Whitaker's test. Details of the patients and the results of the investigations are summarized in Table 1. One patient (no. 1) had previously undergone an unsuccessful balloon dilatation, complicated by urinary extravasation. Another patient (no. 2) had a failed endopyelotomy. The others presented for primary treatment.

Laparoscopic technique

The patient is positioned laterally, as close to the edge of the operating table as possible (Fig.1) and with the theatre floor plan as shown in Fig. 2. Only one video monitor is used for the operation, as positioning the surgeon and assistant on the same side facilitates eye–hand co-ordination.

A pre-operative enema is administered to empty the patient's colon. An intraperitoneal technique is then used; with the patient in the lateral position, a 10 mm Hasson cannula is introduced by open laparoscopy and a pneumoperitoneum created to a pressure of 12 mmHg. Two 6 mm instrument cannulae are introduced under direct internal vision, one in the ipsilateral upper quadrant avoiding the falciform ligament and the other between the umbilicus and symphysis pubis close to the midline (Fig. 3). The position of these instrument trocars is critical to facilitate intracorporeal suturing of the anastomosis, as placing the instrument trocars too laterally will hamper the surgeon's ability to suture. A further instrument port is required for a right pyeloplasty, to retract the overhanging edge of the liver. The colon is mobilized and allowed to fall away from the renal bed, exposing Gerota's fascia. The key to this procedure is to

Accepted for publication 6 February 1996

Table 1 Characteristics of patients undergoing laparoscopic pyeloplasty

Patient no.	*Age (years)*	*Side*	*Duration of surgery (min)*	*Isotope renography half-time (min)*		*Outcome*	*Comments*
				Before	*After*		
1	15	L	120	19	9	Converted	Previous failed balloon dilatation Extensive fibrosis around PUJ
2	8	L	150	122	46	Completed	Previous failed endopyelotomy
3	9	L	160	20	10	Completed	Abdominal wall haematoma
4	9	R	90	45	5	Completed	
5	8	L	93	23	100	Completed	Improved diff. function
6	2.5	L	90	60	9	Completed	Hynes-Anderson

Fig. 1. The position of the patient on the operating table.

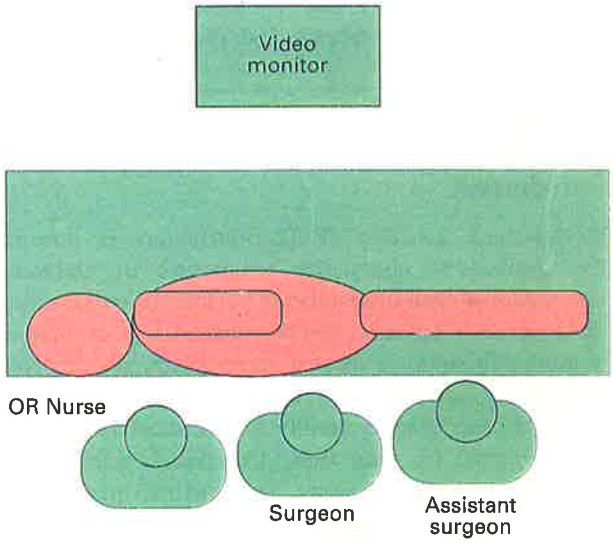


Fig. 2. The theatre layout and personnel for laparoscopic pyeloplasty.

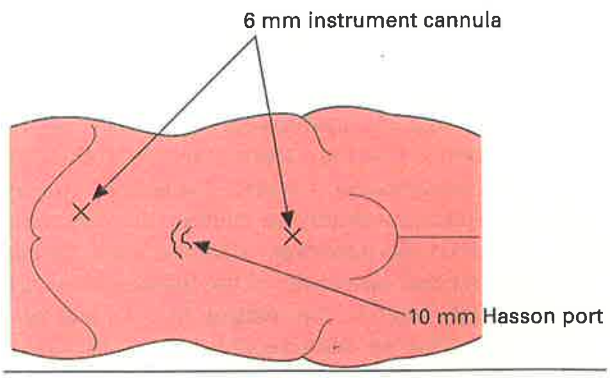


Fig. 3. The positioning of the ports in the patient.

completely divide the fold of peritoneum attaching the colon to the lateral abdominal wall (Fig. 4a).

An incision is then made in Gerota's fascia (Fig. 4b), exposing the entire kidney (Fig. 4c). The dilated pelvis is identified and traced medially to the PUJ. Care must be taken when dissecting the pelvis to avoid inadvertent damage to the gonadal vessels which cross directly in front of the PUJ.

Once the proximal ureter and renal pelvis are mobilized (Fig. 4d), the pelvis is stabilized using a single transabdominal 'hitch-stitch' (Fig. 5a), accomplished by passing a 4/0 monofilament nylon on a straight needle through the full thickness of the abdominal wall, transfixing the renal pelvis, and passing the suture through the abdominal wall at its entry point, using an endoscopic needle-driver. The hitch-stitch is then held by a haemostat at

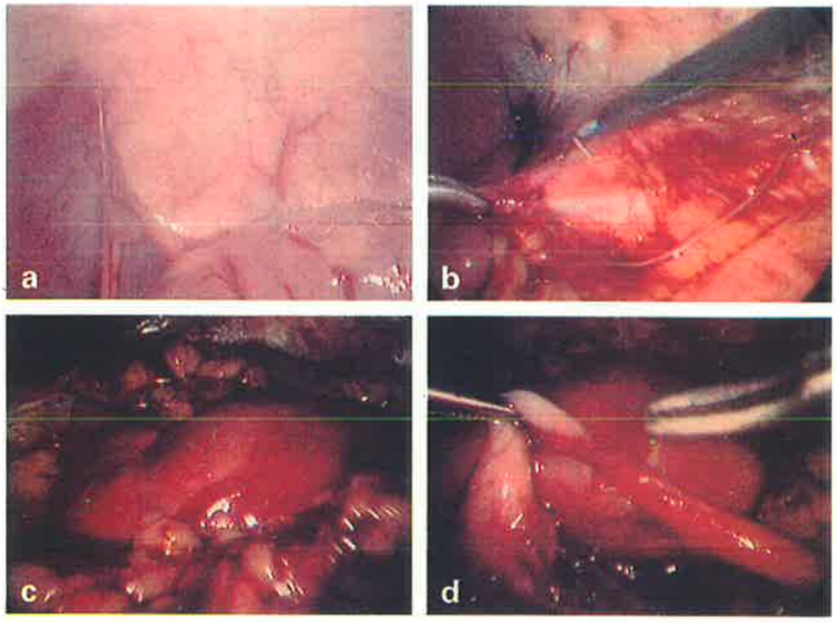


Fig. 4. **a**, Key to Gerota's fascia. **b**, Opening Gerota's fascia. **c**, Kidney exposed completely. **d**, PU junction mobilized.

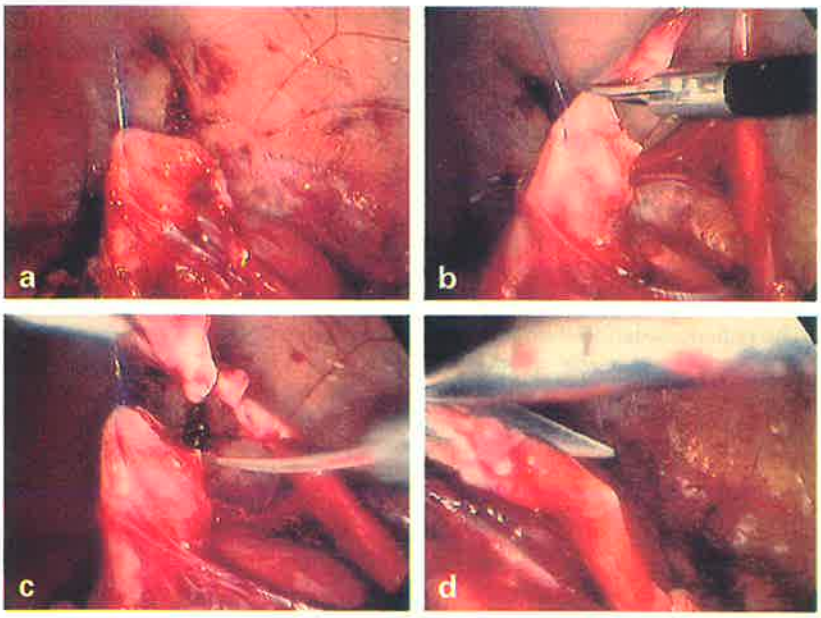


Fig. 5. **a**, 'Hitch stitch' in place. **b**, Dismembering PUJ. **c**, Dividing proximal ureter. **d**, Spatulating proximal ureter.

the level of the abdominal wall, after applying appropriate tension on the suture to stabilize the pelvis.

In four patients, a longitudinal incision was made from the pelvis across the PUJ into normal ureter and re-anastomosed transversely, effectively creating a Y–V plasty. The sixth patient in the series had a formal dismembered Hynes–Anderson pyeloplasty, whereby the PUJ was resected and the proximal ureter spatulated (Fig. 5**b**,**c**,**d**).

The first stitch is inserted into the ureter at its most dependent position (Fig. 6**a**) and this is then re- anastomosed to the most dependent part of the renal pelvis (Fig. 6**b**). The anastomosis is performed with 5/0 continuous polydioxanone sutures, the posterior layer being completed first (Fig. 6**c**).

A double pig-tail catheter is then inserted by introducing a transabdominal guidewire into the proximal ureter through a Teflon needle, and passing it into the bladder. The Teflon needle is withdrawn, leaving the guidewire in place, and a 4.8F multilength pig-tailed catheter

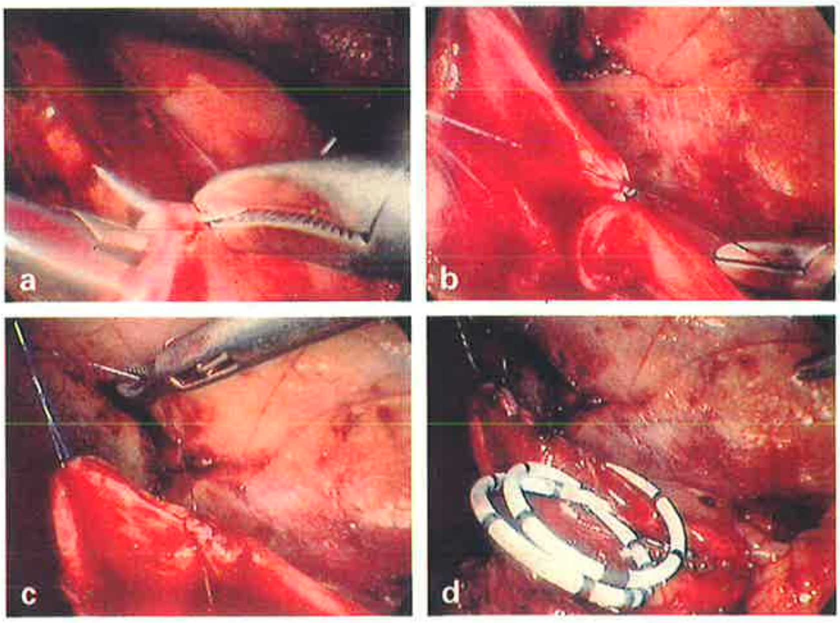


Fig. 6. **a**, First suture at apex of ureterotomy. **b**, Anastomosing ureter to pelvis. **c**, Completed posterior layer. **d**, Pig-tail catheter *in situ*.

passed over the guidewire into the bladder. The guidewire is withdrawn and the proximal pig-tail inserted into the renal pelvis (Fig. 7**a**).

The anterior anastomosis is completed over the pig-tailed stent with a second continuous 5/0 polydioxanone suture (Fig. 7**b**). The hitch-stitch is then removed, allowing the renal pelvis to fall back into its bed (Fig. 7**c**,**d**). The abdomen is then desufflated. The umbilical trocar is closed with an 0 polyglactin suture, while the smaller instrument ports are simply re-approximated with adhesive strips to the skin. No drains are used.

The patients were discharged on the day after surgery and remained on antibiotics until the stent was removed as a day-surgical procedure after 6 weeks. All patients were evaluated 6 months after the operation by isotopic renography.

Results

The results are summarized in Table 1; the first attempt (patient no. 1) was converted to an open procedure because extensive peri-ureteric fibrosis prevented adequate mobilization of the PUJ and it was this patient who had undergone a previous and unsuccessful balloon dilatation

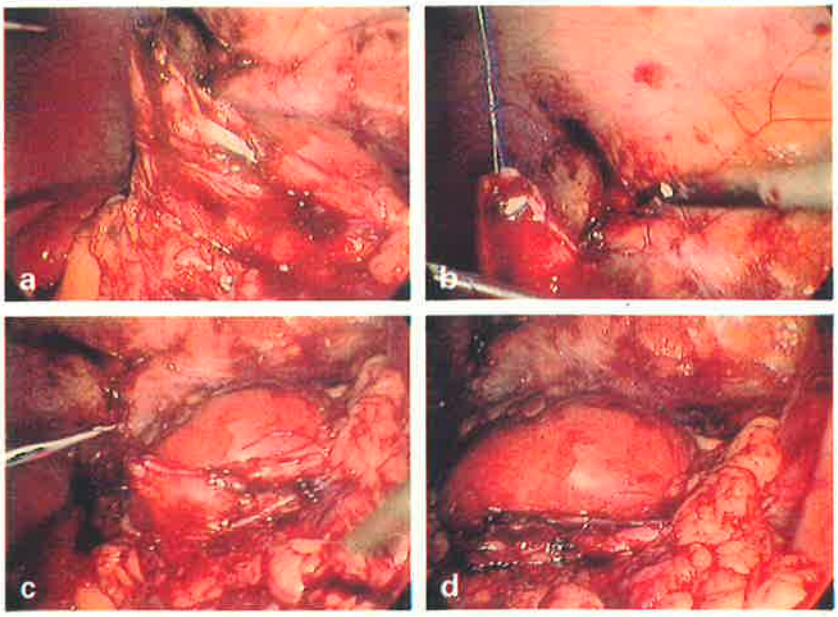


Fig. 7. **a**, Pig-tail catheter placed in pelvis. **b**, Anterior anastomosis complete. **c**,**d**, Kidney and pelvis returned to renal bed.

of the PUJ. Excluding this case, the median operative time for laparoscopic pyeloplasty was 117 min (range 90–160). While the first two cases took 150 and 160 min, respectively, all subsequent cases were completed within 90 min. One patient required re-admission on the third day after surgery because of an abdominal wall haematoma which settled with conservative measures. Four of the six patients had normal drainage half-times on post-operative renography, indicating a successful outcome. A further patient had a significant improvement in the drainage half-time after surgery. One patient had a deterioration in drainage, although the differential renal function of the operated kidney was improved from 28% to 42%, and this patients is awaiting further investigation.

Discussion

Laparoscopic pyeloplasty completes a range of minimally invasive surgical options to treat PUJ obstruction. Balloon dilatation of the PUJ and endopyelotomy have both been used in children with promising results reported, but not all patients are suitable for these techniques and the success rate of these procedures is still inferior to conventional open pyeloplasty [1,2]. Because it involves endoscopic suturing, pyeloplasty is one of the most technically difficult of laparoscopic procedures; however, the present series shows that with adequate practice and experience, it is both feasible and safe. The operative time ranged from 90 to 150 min, which is considerably less than has been reported previously in adults [3–5] or children [6] and approaches the time taken for conventional open pyeloplasty.

The present technique evolved with practice; the original option of performing a Y-V plasty was intended to preserve the continuity of the ureter and pelvis to facilitate endosuturing. Confidence with the first few cases, and the use of the hitch-stitch, allowed the pelvis to be stabilized sufficiently to perform a formal dismembered pyelopasty. One case of failed endopyelotomy was treated successfully by laparoscopic pyeloplasty with no extra difficulty. Only one case (the first) was converted to a conventional open procedure because there were extensive peri-ureteric adhesions following a previous ureteric rupture. A few cases may not be amenable to a laparoscopic approach due to such problems, but these should become even fewer as experience is gained with the technique.

Laparoscopic pyeloplasty has the theoretical disadvantage of converting an extra-peritoneal procedure to intra-peritoneal, with the risk of intra-peritoneal adhesions. However, the senior author has encountered severe abdominal adhesions at laparoscopy in patients who have undergone previous extra-peritoneal renal operations, and thus we question this reasoning [7]. Furthermore, the extremely low incidence of intra-abdominal adhesions after laparoscopic surgery, combined with the advantages of the minimally invasive approach to PUJ obstruction, justifies an intra-peritoneal approach. Laparoscopic dismembered pyeloplasty is a promising alternative to conventional open pyeloplasty.

Nevertheless, it remains a technically difficult endoscopic exercise and, because their limited size hinders suturing, is currently unsuitable for very small infants. Our early results are sufficiently encouraging to persist with the evaluation of this technique.

References

1 Tan HL, Roberts JP, Grattan-Smith D. Retrograde balloon dilatation of ureteropelvic obstruction in infants and children: early results. *Urology* 1995; **46**: 89–91
2 Tan HL, Najmaldin A, Webb DR. Endopyelotomy for pelvi-ureteric junction obstruction in children. *Eur Urol* 1993; **24**: 84–8
3 Kavoussi LR, Peters CA. Laparoscopic pyeloplasty. *J Urol* 1993; **150**: 1891–4
4 Schuessler WM, Grune MT, Tecuanhuey LV, Preminger GM. Laparoscopic dismembered pyeloplasty. *J Urol* 1993; **150**: 1795–9
5 Recker F, Subotic B, Goepel M, Tscholl R. Laparoscopic dismembered pyeloplasty: a preliminary report. *Urology* 1995; **153**: 1601–4
6 Peters CA, Schlussel RN, Retik AB. Pediatric laparoscopic dismembered pyeloplasty. *J Urol* 1995; **153**: 1962–5
7 Tan HL. Dialogues in Paediatric Urology 1995; **18**: 4–6

Authors

H.L. Tan, MBBS, FRACS, Consultant Paediatric Surgeon.
J.P. Roberts, MB, BS, FRCS, Consultant Paediatric Surgeon, currently at The Sheffield Children's Hospital.
Correspondence: Dr H.L. Tan, Gleneagles Medical Centre #07–06, 6 Napier Road, Singapore 258499.

Laparoscopic Anderson-Hynes Dismembered Pyeloplasty in Children

By Tan H.L.

Presented at American Academy of Pediatrics
Urology section
Annual Scientific meeting
San Francisco 17th October 1998

Accepted for publication Journal of Urology

Address for correspondence
Hock Lim TAN
Associate Professor of Surgery
Department of Surgery
The Chinese University of Hong Kong
Prince of Wales Hospital
Shatin N.T.
Hong Kong
SAR China
email: hockltan@yahoo.com

Keywords:
Laparoscopy, dismembered pyeloplasty, Anderson-Hynes, Children

Abstract

Objective: To evaluate the feasibility of, and report on the results of laparoscopic Anderson-Hynes dismembered pyeloplasty in children.

Patients and Methods: A retrospective review of all laparoscopic Anderson-Hynes Pyeloplasties performed by the author is presented. Eighteen (18) children with proven uretero-pelvic junction obstruction (UPJO) underwent laparoscopic Anderson-Hynes dismembered pyeloplasty between August 1994 and June 1998. Fifteen pyeloplasties (15/18) were performed on children without previous upper tract surgery. Three patients (3/18) had previous upper tract surgery, two having had previous laparoscopic pyeloplasties. The third patient underwent emergency percutaneous nephrostomy drainage of a pyonephrosis six weeks earlier. All operations were performed via a transperitoneal route. The age ranged from 3 months to fifteen years (Mean = 17 months).

Results Post operative evaluation are completed in sixteen patients, with two pending. Fourteen of sixteen (14/16), or 87% have no demonstrable evidence of obstruction. Two (2/16) patients had persistent obstruction and had to undergo a second laparoscopic pyeloplasty. These two re-operations are part of the total of eighteen.

There was no conversion to open surgery. The mean operating time was 89 minutes. One patient developed a trocar haematoma which resolved with bed rest. In another, the stent was misplaced, its distal end reaching the lower ureter. This was removed via ureteroscopy six weeks after operation. There were no other operation related morbidity.

Conclusion: Laparoscopic Hynes-Anderson Pyeloplasty offers an attractive alternative to conventional open pyeloplasty. It is technically challenging but with practice, can be completed in the same time as conventional open pyeloplasty. It offers results approaching that of conventional dismembered pyeloplasties.

Keywords:
Laparoscopy, dismembered pyeloplasty, Anderson-Hynes, children

Introduction

Although endopyelotomy[1] (pyelolysis) and retrograde dilatation[2,3] is offered as alternative methods of management of UPJO in children, the success with these two procedures is inferior to that reported for conventional dismembered pyeloplasty. Hence, Anderson-Hynes pyeloplasty remains the "gold standard" , and the preferred method of management of UPJO in children[4]. Laparoscopic Anderson-Hynes pyeloplasties however are rarely performed there being only two other reports of laparoscopic Anderson-Hynes dismembered pyeloplasty in children to date [5,6] since its description by Kavoussi and Peters [7].

This paper investigates the feasibility of, and reports on the results of laparoscopic Anderson-Hynes dismembered pyeloplasty in children.

Between August 1994 and June 1998, eighteen (18) children presenting with proven uretero-pelvic junction obstruction (UPJO) underwent laparoscopic dismembered pyeloplasty regardless of age. There were fifteen (15) primary procedures. Three (3) patients had undergone previous surgical intervention to the upper tracts (two failed dismembered pyeloplasties, one percutaneous nephrostomy for pyonephrosis). The age range was 3 months to fifteen years of age (Mean age at operation = 17 months).

All children were pre-operatively investigated with isotopic renography (MAG3 or DTPA) ultrasound, and intravenous urography (IVU). Pre-operative IVU was performed in all patients for anatomical studies and also because many patients were referred from surrounding regional centers often lacking in isotope renogram facilities. Follow up studies were performed where possible with isotope renography, but in those patients from remote areas, IVU studies were performed instead by the local referring physician and sent to the author for post operative evaluation.

Laparoscopic technique

The laparoscopic technique has previously been described by the author[5] and has changed little since the original description except that the anastomoses were all completed in the last eight (8) patients with 6/0 polydioxanone suture due to the availability of laparoscopic micro-instruments. The procedure is now performed using a 7mm umbilical Hasson trocar, and two 6mm instrument trocars. The fourth trocar, previously reported as being necessary to retract the liver for right sided operations, is no longer used.

Gerota's fascia is opened with very limited mobilization, and the uretero-pelvic junction (UPJ) identified by tracing the dilated renal pelvis medially until the gonadal vessels are seen crossing the Pelvis. The UPJ, intimately related to the gonadal vessels, can be identified by lifting the renal pelvis up towards the anterior abdominal wall (fig 1). We have not found it necessary to insert a ureteric catheter as a pre-operative measure to identify the UPJ. The Pelvis is then stabilized with a "hitch stitch" by passing a straight suture through the anterior abdominal wall, suturing the pelvis and passing the suture through the same entry point on the abdominal wall (fig 2). External traction on the suture will then stabilize the pelvis sufficiently to perform the anastomosis.

The Pelvis is dismembered together with the proximal ureter (Fig 3a). This ureter is then spatulated along its lateral margin (Fig 3b) using the renal pelvis to correctly orientate the ureter. The UPJ is then sacrificed after spatulating a sufficient length of ureter to perform a wide anastomosis to the renal pelvis.

Anastomosis is begun by the accurate placement of a suture at the apex of the spatulated ureter, taking care not to create a mucosal flap. This is sutured to the most dependent part of the pyelotomy and the two dismembered ends are re-approximated with an intra-corporeal knot (fig 4). No attempt is made to reduce the size of the Pelvis.

The posterior anastomosis is then completed with a continuous suture (fig 5), the suture being locked at the apex. A trans-anastomotic stent is placed by inserting a long 19Fr Teflon catheter through the anterior abdominal wall, and steering it into proximal ureter. A straight guide wire is then passed through this into the bladder . The Teflon catheter is then withdrawn, and a 3.8Fr or 5Fr variable length double pig-tailed catheter is passed over this guide wire in an antegrade fashion into the bladder. The proximal end is placed in the renal pelvis (fig 6). The anastomosis is then completed by closing the pyelotomy and anterior layer (fig 7) with a second continuous suture.

The hitch stitch is then removed, the UPJ allowed to drop back into its renal bed, and the proximal ureter and pelvis inspected to ensure that it is not kinked, before desufflating the abdominal cavity.

Unlike others who have reported average operating times of ranging from 120 to 530 minutes[8,9] we have been able to complete the entire operation within an average time of 90 minutes (range 70-160mins), and this is by manual intracorporeal suturing of all anastomoses.

This reduction in operating time has been gained through a process of refinement, by recording each operation in its entirety and critically reviewing each video to improve on the ergonomics of this procedure.

Laparoscopic intracorporeal micro suturing is technically challenging, and is perhaps one of the most daunting tasks facing even a skilled laparoscopic surgeon. However, several steps have been adopted by the author in this operation which have enhanced the ease of endoscopic suturing.

An important key to fine intracorporeal endoscopic suturing is to provide stability along the anastomotic line. The "Hitch stitch" as previously described, provides this stability, and greatly facilitates suturing. We do not however, recommend using a second hitch stitch on the ureter, as this only serves to distract the anastomosis, and makes it difficult to oppose the ureter to Pelvis. It is also important to leave a long length of suture on the outside of the abdominal wall, so that the tension on the anastomosis can be relaxed if necessary.

Unlike other authors who have reported the pre-operative placement of balloon catheters[9] or stents[10], we have not found this to be particularly useful, as these only hinders the ability to suture the anastomosis. We have not used the automatic laparoscopic suturing machine, as the suture material is not sufficiently fine for pediatric use. Concern must also be expressed at the use of course suture material as calculi have been reported as a post operative complication following the use of 4/0 suture material [10,11]. It has not been necessary to use fibrin glue[12] or other methods of tissue approximation as advocated by others, as we have been able to perform an adequate anastomosis in all our cases.

We have not used a perinephric external drain in any patient, as all our anastomoses are stented with an internal pig-tailed catheter, preventing anastomotic leakage[13]. We also have reason to believe that a wound drain would not be effective, as the urine would merely leak into the peritoneal cavity.

Results

There was no conversion to open operation and all operations were completed laparoscopically. One patient developed a trocar haematoma requiring 4 days of bed rest to resolve. With the exception of this patient, all were discharged on the second post operative day. One patient had a misplaced stent, the distal end lying in the distal ureter. This stent was removed at six weeks via a ureteroscope. There were no other technically related complications in our series. Blood loss was negligible in all patients.

All stents were removed after 6-8 weeks, and post operative DTPA, MAG3 or IVU were performed at six months or earlier if indicated. Two patients underwent pyeloplasties when they were three months old, and these are the patients that account for the failures in our series. In both instances, the respective kidneys became palpable after removal of the double pig tailed catheter, and they developed clinical signs of acute obstruction with vomiting. Complete obstruction was demonstrated in both instances.

The first patient underwent a repeat laparoscopic dismembered pyeloplasty on the immediate diagnosis of persistent obstruction. He has undergone post operative investigations which has demonstrated good post operative drainage. The second patient underwent a percutaneous nephrostomy inserted in my absence as an emergency procedure. He has also undergone a repeat laparoscopic dismembered pyeloplasty, had his pig tailed catheter removed, is well, and is pending further evaluation.

Sixteen (16) out of the total of eighteen (18) dismembered pyeloplasty units have completed post operative evaluation, with only two remaining to be evaluated including this second of the failure in our series. Fourteen patients have demonstrable relief of obstruction, making our success rate 87% ($^{14}/_{16}$). Although this is not as good a result as has been reported for open pyeloplasty, it is clearly approaching the results attainable with conventional open surgery.

Both our failures to date have been in children operated on at three months of age. Both failures were a result of anastomotic stenoses in spite of trans-anastomotic stenting. In retrospect, these operations were technically extremely challenging, the anastomoses being particularly difficult because of the small caliber of the ureter. This was further compounded by the inability to use a 3.8Fr trans-anastomotic stent, due to inability to pass it through the uretero-vesical junction and smaller 3Fr stents were used instead.

In the light of these problems, we advise against performing laparoscopic Anderson-Hynes dismembered pyeloplasty in children less than six months old.

Discussion

Although other authors have discounted laparoscopic dismembered pyeloplasty as being too difficult to become an acceptable procedure[14], we believe that the refinements achieved by us makes it possible for a skilled laparoscopic surgeon to perform a good anastomosis and in good time[6]. The results achievable with laparoscopic dismembered pyeloplasty are also fast approaching that for conventional open dismembered pyeloplasty, and one must today consider laparoscopic Anderson Hynes dismembered pyeloplasty as an attractive and viable alternative to conventional operation. It offers far superior cosmetic results and is far less debilitating for the patient. However, we do not recommend it for children less than six months of age at this point in time.

We have inserted trans-anastomotic stents in all our cases. While this requires a second outpatient procedure to remove the stent subsequently, we believe the advantages of a trans-anastomotic stent in preventing urinary leak outweighs its disadvantages. Furthermore, we have been routinely stenting our open Anderson-Hynes pyeloplasty hence this is no different from our management of open pyeloplasty.

The fact that it is a transperitoneal operation may raise some concern about adhesion formation, but it must be noted that there is only very minimally mobilization of the Lieno colic ligament, which at the end of the procedure, is completely covered by the colon which flips back into place. This amount of mobilization is not more than at laparoscopy for an undescended testis or varicocelectomy. There is also no bowel handling at all throughout the procedure.

It may be possible with refinement in technique to perform this entirely retroperitoneally. For the moment, the transperitoneal route is preferred because of the space required to perform intra-corporeal suturing.

Conclusion

In conclusion, laparoscopic Hynes-Anderson dismembered pyeloplasty is now a feasible and attractive alternative to open surgery. Undoubtedly requiring a high level of skill and understanding of the ergonomics of laparoscopic surgery, it can nevertheless be learned and performed in the same time as conventional open surgery[6]. Its results are approaching that of conventional open surgery.

1. Tan H.L., Najmaldin A., Webb D.R.
Endopyelotomy for Pelvi-Ureteric Junction Obstruction in Children
Eur Urol 1993; 24:84-88

2. Tan H.L., Roberts J.P., Grattan-Smith D
Retrograde Balloon dilatation of ureteropelvic obstructions in infants and children:
Early results
Urology 1995; 46(1):89-91

3. Doraiswamy NV:
Retrograde ureteroplasty using balloon dilatation in children with pelviureteric obstruction.
Br J Urol 1993 71:152-155

4. Ahmed S, Crankson S., Sripathy V
Pelviureteric obstruction in children: Conventional pyeloplasty is superior to Endo-urology
Aust N.Z. J Surg. (1998) 68;641-642

5. Tan H.L., Roberts J.P.
Laparoscopic dismembered pyeloplasty in children: Preliminary results
Br J Urol (1996) 77; 909-913

6. Schier F
Laparoscopic Anderson-Hynes pyeloplasty in children.
Pediatr Surg Int (1998) 13: 497-500

7. Kavoussi L.R., Peters C.A.
Laparoscopic pyeloplasty
J. Urol 150: (1993) 1891-1894

8. Eight cases of pyelo-ureteral junction syndrome treated by laparoscopic surgery (French)
Brunet p, Leroy j., Danjou P.
Chirurgie. 1996 121(6); 415-417

9. Nakada SY, McDougall EM, Clayman RV
Laparoscopic Pyeloplasty for secondary ureteropelvic junction obstruction: preliminary experience
Urology 1995 46(2); 257-260

10. Moore RG, Averch TD, Schulam PG, Adams JB, Chen RN, Kavoussi LR
Laparoscopic Pyeloplasty: Experience with the initial 30 cases
J Urol 1997 157(2) 459-462

11. Eden CG, Sultana SR, Murray KH, Carruthers RK
Extraperitoneal laparoscopic dismembered fibrin glued pyeloplasty: medium term results.
Br J Urol 1997 80(3) 382-389

12. Eden CG, Coptcoat
Assessment of alternative tissue approximation techniques for laparoscopy
Br J Urol 1996 78(2); 234 - 243

13. Woo HH, Farnsworth RH
Dismembered pyeloplasty in infants under the age of 12 months
Br J Urol 1996 77(3);449-51

14. Janetschek G, Peschel R, Bartsch G
Laparoscopic and retroperitoneoscopic kidney pyeloplasty (German)
Urologe- Ausgabe 1996: 35(3) 202-207

Laparoscopic Anderson - Hynes dismembered pyeloplasty
Tan H.L.

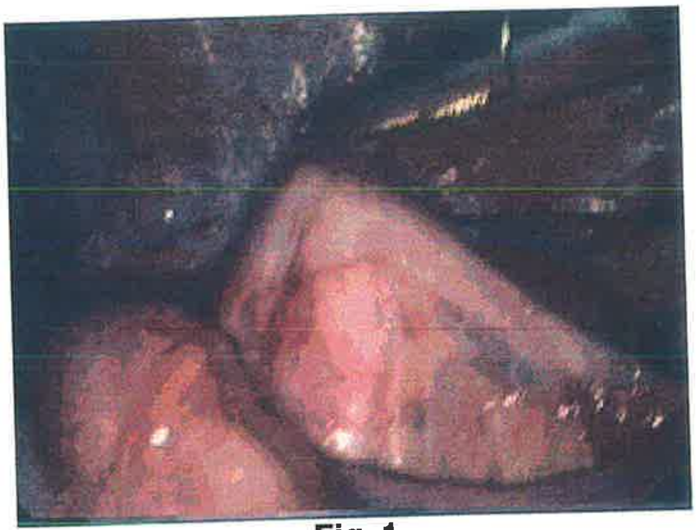


Fig 1
Identifying UPJ by "lifting" renal pelvis up towards anterior abdominal wall

Fig 2
Stabilizing "Hitch Stitch" in situ

Fig 3a
UPJ being dismembered

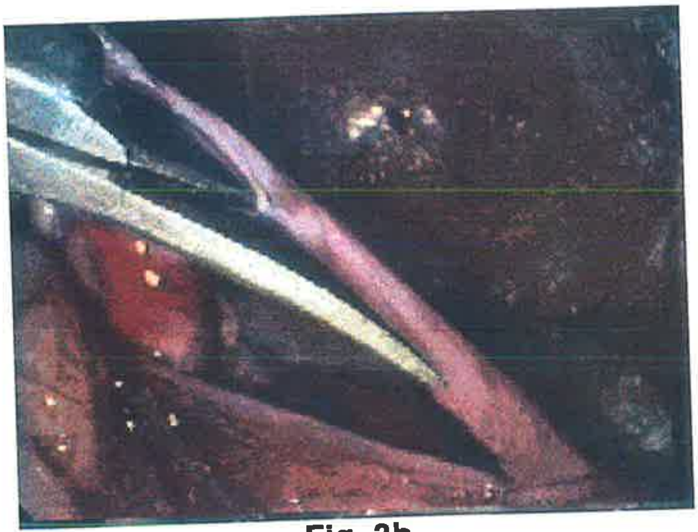


Fig 3b
Ureter being slit opened

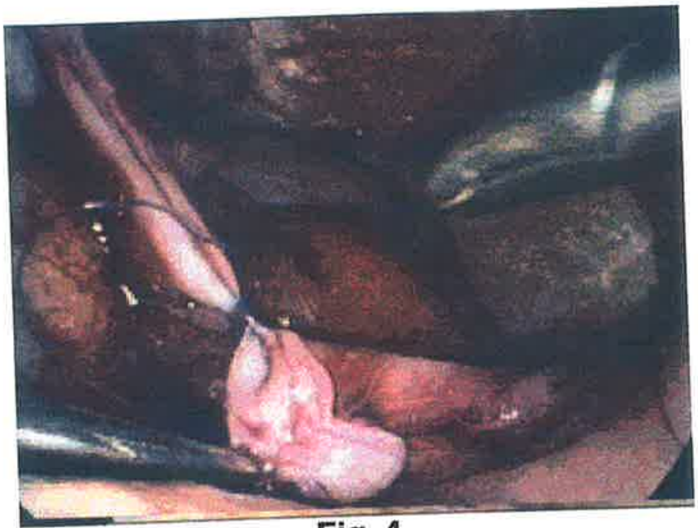


Fig 4
Ureter being re-attached to pelvis

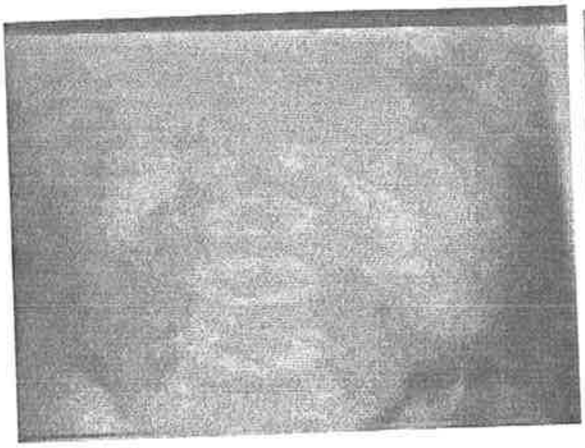
Laparoscopic Anderson - Hynes dismembered pyeloplasty
Tan H.L.

Fig 5
posterior anastomosis completed

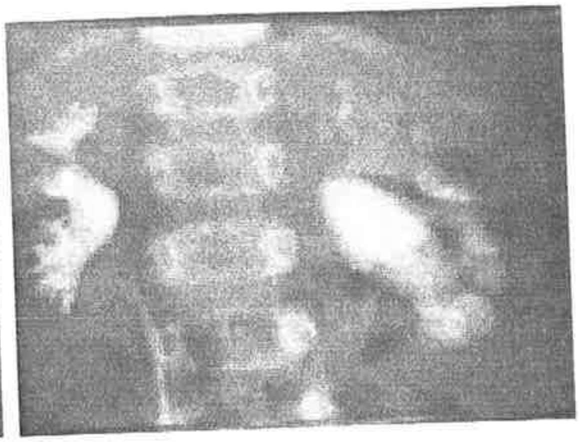
Fig 6
"Double J" being inserted into renal pelvis

Fig 7
Completing anterior anastomosis

Pre and post operative appearance



Pre-operative IVU in six
month old infant



post operative IVU
six months after pyeloplasty

Other developments in Minimally invasive paediatric urology

The first laparoscopic nephrectomy was by Drs. Clayman & Kavoussi in 1991. I had the good fortune to meet Professor Louis Kavoussi when he visited Melbourne in 1993. Dr. Kavoussi's technique had the assistant standing opposite the surgeon and working from a second monitor. The operating times reported by the Clayman/Kavoussi group was also in the order of about five hours, which I felt was excessive in children, and it did take him about 5 hours to perform the life nephrectomy in Melbourne.

After watching him perform the adult nephrectomy, I returned to the laboratory where I performed several operations in piglets to see if the technique could be improved on. Having by now performed a substantial number of laparoscopic procedures in children, and being acutely aware of the importance of correct ergonomics in laparoscopic surgery, I was aware that the floor plan as advocated by Kavoussi was not ideal for the assistant, as he was working *against* the camera, introducing a second order horizontal paradox movement which made the assistant quite useless.

In the laboratory, I confirmed that it was far better ergonomically to position the surgeon, nurse and assistant side by side all the watching only one monitor, and performed several nephrectomies in piglets, before attempting the first nephrectomy in a child. Even though this made the space rather cramped, it appeared to offer the best ergonomics.

The first live nephrectomy was performed in a four year old child presenting with a giant hydronephrotic kidney which reached into the renal pelvis. The total operating time for this was 120 minutes, far less than the average of four to five hours reported by Clayman, probably a result of improved ergonomics!

To date, I have performed a total of 40 laparoscopic nephrectomies of which 13 were partial nephrectomies for duplex kidneys. There were three partial lower pole nephrectomies for non functioning or poorly functioning lower moieties, two end stage kidneys due to severe reflux and one due to an associated uretero-pelvic junction obstruction.

All procedures were performed via the transperitoneal route and there was no conversion to open surgery. One patient with a complete staghorn calculus in a non functioning kidney developed post operative sepsis which was controlled by intravenous antibiotics. In three patients, intraoperative bleeding occurred from division of unrecognised segmental vessels during partial nephrectomy, but these were all controlled laparoscopically without the need to convert. None of these patients required transfusion as the bleeding was quickly controlled

The most serious complication occurred in a patient with pulmonary stenosis who underwent a right lower pole hemi-nephrectomy for a non functioning kidney due to severe reflux, when the ligature to the lower ureteric stump slipped. The patient was "anuric" in the post operative period due to unrecognised urinary extravasation from the ureteric stump, and was given large amounts of intravenous fluid because of the "anuria" which in turn caused the patient to develop pulmonary edema.

Operation time varied from 20 minutes for removal of a multicystic dysplastic kidney to an average of 90 minutes for partial nephrectomy.

Our early results, together with a collection of our total experience in paediatric minimally invasive urology, were published in Dialogues in Pediatric Urology. Of interest is that fact that Dr. Louis Kavoussi in recent discussions with him, has now adopted my floor plan which he agrees is more ergonomic.

The following are papers published in Dialogues in Pediatric Urology and a chapter on paediatric Minimally Invasive Urology book which is in print.

Dialogues in Pediatric Urology

Volume 18, Number 2
February, 1995

This issue's topic:

Minimally Invasive Surgery In Pediatric Urology

Guest Editor: Mr. Hock L. Tan, FRACS

Editor

Richard M. Ehrlich, MD
Clinical Professor of Surgery/Urology
School of Medicine
University of California, Los Angeles

Publisher

William J. Miller

GUEST EDITOR'S NOTES:

The rapid growth in minimally invasive surgery in the past few years has made it practically impossible to keep pace with many of the worldwide developments in this field. A previous issue of *Dialogues* dealt with innovations primarily from the North American continent. This issue will concentrate on some of the developments in this field which have taken place in our institution "Down Under."

Our interest in minimally invasive surgery began in 1986 with the return of David Webb to Australia, following his involvement in the development of percutaneous nephrolithotripsy in the United Kingdom with John Wickham and John Fitzpatrick.

As in our adult urological experience, interest in pediatric percutaneous renal surgery began with the management of renal calculi. We found that extracorporeal shock wave lithotripsy (ESWL) was not the answer to the management of renal calculus disease in our population because of many factors which we will outline. We developed a multimodal management of renal calculi with percutaneous nephrolithotripsy (PCNL) emerging as an important arm of our protocol. After achieving some success with percutaneous nephrolithotomy, we began to perform endopyelotomy, at first on patients with renal calculi and associated ureteropelvic junction (UPJ) obstruction, and then later by extending its clinical applications to patients with primary UPJ obstruction. In spite of the success achieved with this technique, we do not believe that endopyelotomy is the answer for UPJ obstruction in infants and children for many reasons which will be discussed. This prompted us to investigate other alternative methods of treating UPJ obstruction.

Dialogues in Pediatric Urology (ISSN 0164-9507) is published monthly by William J. Miller Associates, Inc. 45 Villa Road, Pearl River, N.Y. 10965. Second class postage is paid at Pearl River, N.Y. 10965. Subscription rates: $54 per year within the United States and Canada; $57 per year elsewhere. Phone numbers: (914) 735-7853; (Fax): (914) 735-6628. Postmaster: Send address changes to Dialogues in Pediatric Urology, 45 Villa Road, Pearl River, N.Y. 10965.

The turning point came in 1989 when I first witnessed laparoscopic cholecystectomy at the initial meeting of the Society for Minimally Invasive Therapy. A major stumbling block, however, was the lack of instrumentation for laparoscopic surgery in infants. Fortunately, we developed instruments suitable for use in infants in conjunction with Karl Storz and, as with others, found increasing clinical applications for laparoscopy. Our first laparoscopic nephrectomy was in 1993 after the visit of Lou Kavoussi. With increasing experience and confidence, we have since performed laparoscopic heminephrectomies and dismembered pyeloplasties. We can now see a potential pathway to treat nearly all kinds of UPJ obstruction through a minimally invasive approach.

The last essay in this issue sounds the only discordant note, but I chose to include it for several reasons. Robert Fowler from our institution has made a significant contribution to the understanding of the vascular supply of the testis. The new-found popularity of the laparoscopic Fowler-Stephens approach to intraabdominal testes has prompted me to consider the possible long-term impact of ligation of the internal spermatic vascular bundle on the testis, and I felt that there is no better person to review the role of laparoscopy than Dr Fowler himself. This issue is therefore about our experiences at the Royal Children's Hospital in Melbourne. I make no apologies for this as the "tyranny of distance" would not otherwise give my Northern Hemisphere counterparts a chance to witness the progress of minimally invasive surgery "Down Under."

Mr. Hock L Tan
Chief of Endosurgery Services, The Royal Children's Hospital, Melbourne, Australia

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EDITOR'S COMMENTS:

I am delighted that Hock Tan has reproduced our series and has expressed enthusiasm for laparoscopy in the pediatric population. This validates our thinking, despite the "tyranny of distance," as we and others continue to march forward.

Arnold Colodny took me to task at the AAP meeting regarding the extraperitoneal approach. Despite his advocacy for this procedure, the extraperitoneal approach in children is more difficult than in the adult. It should not be employed until one is familiar with conventional laparoscopy. Additionally, we have not encountered any intraperitoneal adhesions to date.

Congratulations to Hock and his Australian colleagues, particularly Dr. Fowler, who gives us a balanced presentation documented with references in his critical review, for this thought-provoking issue.

Richard M. Ehrlich, MD

MR. DAVID R. WEBB, FRACS
MR. HOCK L. TAN, FRACS
Endosurgical Services, The Royal Children's Hospital, Melbourne

Intraluminal Surgery of the Upper Tract

Calculus disease is rare in children, and while extracorporeal shock wave lithotripsy (ESWL) is now the treatment of choice in adults with urolithiasis, it has not enjoyed the same success in children. This is because less than half of the cases of urolithiasis in children are suitable for treatment with this technique. Pediatric stones differ in etiology; the majority of stones are either infective or metabolic as opposed to the adult population which are predominantly idiopathic stones. Because of this difference, we developed a technique for percutaneous nephrolithotomy (PCNL) in children that remains the mainstay of treatment in our institution. These percutaneous renal access techniques form the basis of other intraluminal procedures.

Although PCNL can be performed with safety even in small infants, there are some special problems to be considered. Children are susceptible to hypothermia because of their relatively small body mass and the large amount of irrigant solution required for PCNL. A warming blanket under the patient, however, can make it very difficult to visualize faintly radiopaque calculi with an image intensifier, so we advise against placing a water blanket directly under the operative field for this reason. The risk of hypothermia can be minimized by wrapping the extremities and all exposed parts not within the immediate surgical field with cotton wool. A space blanket placed over the child also will minimize heat loss. It is also important to keep the patient dry, as a wet child is a cold child, and a disposable neurosurgical incise drape is an ideal PCNL drape as it is waterproof and allows irrigation fluid to drain away from the operative field into a large collecting bag. Irrigating solutions should be prewarmed as the perfusion of cold irrigation fluid will lead to rapid cooling.

An integral part of percutaneous surgery is the creation of a working tract. Several major differences become evident when one attempts to create nephrocutaneous tracts in children. Bleeding assumes a greater significance because of the smaller overall blood volume, and bleeding within a small collecting system makes visualization extremely difficult. The size of the collecting system in infants also makes percutaneous nephrostomy more difficult since greater precision is required. It often is not possible to leave a long length of guide wire in the collecting system, especially when dealing with a staghorn calculus. This increases the risk of guide wire dislodgment during dilatation of the tract. The kidney in a child also is much more mobile than in an adult, increasing the risk of guide wire dislodgment during dilatation of the tract.

It is common for us to use 10 liters of fluid during a PCNL session, but the risk of fluid overload is minimized by using an open Amplatz operating sheath and a small head of hydrostatic pressure. We abandon PCNL at the first sign of extravasation, leave a nephrostomy, and return 10 days later.

Methods of Dilatation. We evaluated current techniques for creating and dilating a tract to determine the technique most suitable for use in young children. Current accepted techniques are serial Amplatz dilators, balloon dilators or metal telescoping dilators. While these are acceptable in adult percutaneous renal surgery, they can create special problems when applied in children and each of these will be discussed.

Multiple serial dilatation with Amplatz dilators is time-consuming and bleeding occurs during the interchange of dilators due to loss of tamponade. The greatest danger with this technique in small collecting systems is guide wire dislodgment and perforation of the opposite wall of the collecting system. Radial balloon dilatation requires multiple exchanges as well and it can be difficult to leave a sufficient length of balloon in a small collecting system for it not to slip out when the balloon is being inflated. We have found this method unsuitable in children. The metal telescoping dilator causes minimal bleeding but it can be difficult to maintain the position of the metal rod during dilatation. We have found that the kidney moves away during dilatation as it is more mobile in a child.

We have developed a single increment dilator which is roughly pencil-shaped and fits snugly over a 0.032" guide wire. Dilatation is performed in a single stage by first puncturing the kidney with a 19-gauge teflon needle and introducing the 0.032" guide wire into the collecting system. The teflon needle is withdrawn and the single incremental dilator passed over the guide after dilating the lumbar fascia with a pair of straight haemostats. Very little bleeding is seen using this technique as the tract is tamponaded by the working sheath. Most pediatric stones can also be extracted through small diameter Amplatz sheaths. We use a 14 Fr tract for endopyelotomy and a 16 to 18 Fr tract for lithotripsy. We do not use a nephroscope for lithotripsy as the smallest diameter scope is 18 Fr. Instead, we use an 11 Fr operating cystoscope (such as that used for the STING) with an offset eye piece which has an operating channel that can accommodate a 5 Fr probe for the ultrasonic lithotripter to fragment the calculi. We evaluated the damage caused by this single incremental dilator in the laboratory and have not found any differences in the damage caused by it compared to conventional techniques and use this technique by choice.

Results. We have managed 60 patients with urinary tract calculi since 1986. With the exception of two patients, all were successfully managed without open surgery. One of these weighed 1.3 Kg and was an ex-premature infant of 24 weeks gestation with severe bronchopulmonary dysplasia. He underwent open pyelolithotomy because of a large obstructed system with a solitary stone in the pelvis. A dismemberment pyeloplasty was performed at open surgery. The second patient had an open nephrectomy for a calculus in a nonfunctioning kidney. This patient would probably have undergone laparoscopic nephrectomy today.

ESWL was successful as the only mode of treatment in 16 patients (26%). Thirty patients (50%) required PCNL alone, five (8%) had ESWL and PCNL, and five patients (8%) were treated with a combination of ESWL, PCNL and chemolysis. One patient had chemolysis alone through a percutaneous nephrostomy. One ureteric stone passed spontaneously on percutaneous drainage of an obstructed system.

Our results differ markedly from that reported in adult services where the majority of stones can be successfully treated by ESWL. This is a reflection of the etiology, as only 35/60 (58%) of patients had normal upper tracts, and of this group, 14 patients had metabolic stones (six, cystine; seven, uric acid; one, oxaluria). There were six Australian aboriginal infants in our series all presenting with hematuria and radiolucent uric acid calculi in undilated, nonobstructed systems. These are presumed to be metabolic in origin as these patients all live in the harsh Australian desert environment. The other patient with uric acid calculus was undergoing chemotherapy for a malignancy.

Twenty-six stones were infective in origin (41%), and seven others (12%) had pre-existing renal tract abnormality such as reflux, obstructive uropathy or previous renal surgery. The majority of renal stones in our series, therefore, have an underlying etiology. Our use of Renicidin in the chemolysis of infective stones is particularly interesting. We have used Renicidin either on its own or following PCNL to clear residual stones and have found it useful.

Morbidity. Seven patients with staghorn calculi became septic postoperatively in spite of perioperative antibiotic cover. One of these became hypotensive from endotoxic shock and required cardiovascular support in intensive care for 24 hours. Clearly, perioperative antibiotic cover is mandatory. One patient required a two-unit transfusion. She was a teenager with a complex bilateral staghorn calculus who underwent bilateral PCNL at the same sitting. However, this was one of our earlier patients and she underwent multiple serial dilatations to create the tract.

Unlike others, we have found ESWL to have a limited role in the management of pediatric calculi but have found PCNL to be safe and effective in the management of difficult pediatric urinary calculi. Except for sepsis, no significant complications have occurred. Blood loss is minimal when employing a single incremental dilator to create the tract even in a patient as young as 16 weeks old who is our youngest to date.

Other Clinical Applications. Stent migration is an uncommon problem. We have had six children with either broken or migrated double pigtailed catheters which have been successfully removed percutaneously. This is a good indication to perform PCNL as the procedure is usually quick and can be performed through a small sheath (12 Fr) with a small cystoscope.

Pediatric endopyelotomy has been previously reported by us and our success rate (77%) is similar to that reported in adult series. We perform this procedure through a small Amplatz sheath (14 Fr) using a 11 Fr resectoscope with a backward cutting cold knife. Two guide wires are passed through the narrow UPJ and the resectoscope is passed between the guides which splays open the UPJ allowing for easy pyelolysis. The UPJ is stented with an externalized 8.5 Fr nephrostomy stent with a tail extending into proximal ureter.

Even though we have demonstrated that endopyelotomy works just as well in children as in adults, we have found it to be less than an ideal procedure for many reasons. The main technical drawback is the need to place an external nephrostomy stent as pediatric ureters will not accommodate an 8 Fr double-pigtailed stent. Externalized nephrostomies are not well tolerated by many children and parents even though they cause minimal discomfort. We have also found endopyelotomy to be unsuitable for infants, the limiting factor being the size of the stent since it is not possible to pass a 8.5 Fr stent through into the distal ureter. We have attempted endopyelotomy using a 5 Fr stent but have found that this is too small to maintain patency of the UPJ. For the same reason, we have not attempted the Clayman accusize endopyelotomy because this requires the passage of a 8 Fr retrograde catheter.

These technical limitations, we think, will restrict endopyelotomy to the treatment of secondary UPJ obstruction in the future, but it is a technique that works well in children if it works. Our experience is that long-term patency can be achieved with endopyelotomy. We have now followed children who had successful endopyelotomy for three to five years and have not encountered any late re-obstruction any patient.

Our experience with percutaneous renal surgery is that it is safe, but meticulous attention to detail is required to prevent hypothermia, blood loss, loss of tract and sepsis.

MR. HOCK L TAN

Laparoscopic Nephrectomy and Partial Nephrectomy

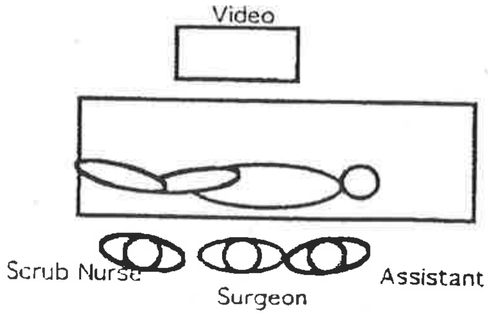
Since Clayman and Kavoussi described laparoscopic nephrectomy in adults, several pediatric urologists have reported laparoscopic nephrectomies in children. We have performed a total of 23 nephrectomies in children, including six partial nephrectomies without conversion to open nephrectomy. We would like to describe our technique and some variations we developed.

Operative Details. We administer an enema prior to a left nephrectomy since a colon full of feces may impede its mobilization. A silastic urethral catheter is inserted pre-operatively; the intravenous line should be on the same side as the kidney to be removed so that the arm can then be placed in a convenient position for easy access by the anaesthetist. We have not found it necessary to insert a ureteral stent as the ureter is easily identifiable at the pelvic brim. The patient is securely positioned in the lateral decubitus position as close to the edge of the table as possible, slightly off the vertical with the lumbar spine supported by a bean bag or a soft cushion. The entire abdomen is prepped and draped.

Theatre Layout. The floor plan is as shown below. We prefer to position the surgeon and assistant on the same side and to use only one monitor. This allows both the surgeon and assistant to be in the same line of vision and facilitates eye-hand coordination, particularly that of the assistant surgeon. Placing the assistant on the opposite side of the table with his own monitor, we have found, introduces an additional degree of paradoxical movement for the assistant who has to work against the video camera.

Trocar Position. All laparoscopic procedures in our institution are performed by open laparoscopy. A supra-umbilical circumferential incision is made in the skin crease above the umbilicus and a small transverse incision made in the linea alba, 1 cm above the skin incision. The peritoneal layer is then identified and carefully opened,

OR Floor Plan



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taking care not to injure viscera at this stage as the contents tend to spill out because of the patient position.

An 0 Vicryl (UR6 needle) purse-string is placed around the linea alba incision and a 10 mm blunt Hasson cannula is introduced, directed upwards to the ceiling to avoid catching omentum. The purse-string is tightened around the Hasson cannula with a single throw and hitched to the ligature holder. The abdomen is then insufflated to 12 mm/ Hg pressure with CO_2. At least two other 6 mm instrument cannulae are required, one in the ipsilateral iliac fossa avoiding the inferior epigastric artery and a second in the ipsilateral upper quadrant. A third 6 mm instrument cannula is sometimes required for right nephrectomy to retract the overhanging liver edge.

We use an intraperitoneal approach, and begin by detaching the colon from its lateral peritoneal attachment. A clear fold of lienocolic ligament can be identified on the left, and division of this with limited mobilization of the colon will expose Gerota's fascia and the kidney.

Colonic mobilization is slightly more difficult on the right because of the overhanging liver edge. The ureter is easily identified at the pelvic brim, where it is not enveloped in fat as it approaches Gerota's fascia. The ureter is divided and both ends ligated with a Surgitie. The distal ureter can be followed to the base of the bladder, but care must be taken not to damage the vas which crosses the ureter in the pelvis. Gonadal vessels cross the ureter and should be preserved. The femoral and ilio inguinal nerves and lumbar sympathetic chain are all at risk in retroperitoneal dissection and care is taken not to damage these.

Traction upwards on the ureter exposes the renal hilum. It is easier to leave the kidney in its bed and to dissect the pedicle before mobilizing the kidney because the kidney tends to flop into the operating field and may impede dissection otherwise.

The renal vein is identified in front of and below the renal artery but the artery is clipped first to prevent venous engorgement. We have not found it necessary to use a linear stapler. The clip applicator is introduced through the umbilical cannula and a 5 mm telescope can be inserted into the upper quadrant cannula during this phase of the operation. This saves using a second large cannula. One of the greatest dangers is to miss a posterior segmental vessel or branches to the adrenal gland and to divide them unknowingly after controlling the main vascular branches. We have not found it necessary to identify the renal pedicle when removing multicystic dysplastic kidneys as these vessels are usually rather flimsy and may be diathermied.

Once the kidney has been completely detached, the 5 mm telescope is reintroduced into the upper quadrant port. A grasper is introduced into the 10 mm Hasson cannula and the kidney delivered through this port. We extend the linea alba incision by 1 cm on each side to deliver the kidney intact, and empty large hydronephrotic kidneys or puncture cysts prior to delivering the kidney. We have not found it necessary to morcellate any specimen so far.

Extraperitoneal Nephrectomy. Gaur and Clayman advocate retroperitoneal nephrectomy by making a small incision in the loin, inserting a balloon to develop the retroperitoneal space and inserting instrument trocars between the 12[th] rib and iliac crest. While this may be possible in adults, in infants the distance between the 12[th] rib and iliac crest is barely 3 cm. This does not allow sufficient room to insert instrument ports. The need to follow the ureter to the bladder, particularly for duplex systems, is another reason why the extraperitoneal approach is unsuitable for pediatric nephrectomy.

The main advantage of an extraperitoneal approach allegedly is to avoid developing intraperitoneal adhesions. However, we have encountered dense intraabdominal adhesions at laparoscopy in patients who have undergone previous extraperitoneal operations and seriously question this reasoning.

Results. We have performed 23 laparoscopic nephrectomies of which 17 were total nephrectomies and six were heminephrectomies. There has not been any conversion to open procedure. Of the total nephrectomies, six were end-stage refluxing kidneys, five multicystic dysplastic kidneys, four nonfunctioning obstructed kidneys and two were in patients with renal calculus and a poorly functioning kidney.

All heminephrectomies were for duplex systems. Two lower pole heminephrectomies were performed, one for a nonfunctioning kidney with associated UPJ obstruction of the lower pole moiety, while the other was for a poorly functioning refluxing lower moiety. The four upper pole nephroureterectomies all were for poorly functioning upper moieties subservient to a ureterocele.

Heminephrectomy can be technically challenging. Lower pole heminephrectomies are easier as there is no need to display the renal pedicle. When performing an upper moiety heminephrectomy, we find it best to isolate the ureter below the hilum, divide it and pass it behind the renal pedicle to the upper pole. This allows countertraction on the upper pole to facilitate dissection of the renal pedicle. The distal ureter is excised separately. We have not found it necessary to clip the segmental upper polar vessels in most cases, but have used an exclusive pair of bipolar forceps to coagulate and divide the upper pole kidney bloodlessly. (Tan bipolar forceps - Karl Storz)

Complications have been minimal. One patient with a nonfunctioning kidney and a complete staghorn calculus developed postoperative sepsis, and there were three intraoperative bleeds from missed segmental vessels which were controlled laparoscopically. None of these required transfusion.

One patient with pulmonary stenosis underwent a lower pole heminephroureterectomy for a nonfunctioning lower pole refluxing moiety and developed cardiac failure because of an unrecognized intraperitoneal urinary leak from a slipped ligature to ureteric stump. She settled on urinary drainage for six days without a need to re-explore the distal.

The operating time varied from 20 minutes for a multicystic kidney to four hours for a nephrectomy in a child who had previous open renal surgery. The ease of the procedure is dependent on the pathology, with multicystic kidneys being the easiest.

Conclusion. Nephrectomy and partial nephrectomy offers the patient considerable cosmetic advantage. Although the benefits of laparoscopic surgery evident in adult surgery, such as reduced hospitalization, quicker recovery and less pain, are less obvious in the pediatric age group, it still nonetheless will become accepted if it can to shown to be at least as safe as conventional open surgery.

MR. HOCK L. TAN

Minimally Invasive Management of UPJ Obstruction in Children

Ureteropelvic junction (UPJ) obstruction is one of the most common obstructive uropathies seen in children today, especially with an increasing number being diagnosed antenatally. While the indications for treatment of antenatally diagnosed hydronephrosis and apparent UPJ obstruction remain controversial and will not be discussed here, open dismembered pyeloplasty remains the treatment of choice when an operation is indicated. Open dismembered pyeloplasty is effective treatment, but it is not minimally invasive and sometimes is associated with significant morbidity.

We reported a series in 1993 of 17 children in whom we attempted this procedure. Endopyelotomy was completed in 13 patients with relief of obstruction in 10, giving a success rate of 77%, comparable to that reported in adult series. While endopyelotomy offers a minimally invasive method of treating UPJ obstruction, it is technically a difficult operation, is unsuitable for infants, and the result is still not as good as conventional dismembered pyeloplasty.

Notwithstanding these limitations, endopyelotomy still should be considered for patients with renal calculi secondary to a UPJ obstruction, and particularly for patients with recurrent obstruction following open dismemberment pyeloplasty. Accusize endopyelotomy, as described by Clayman, similarly is not suitable in children for the reasons already outlined.

The advent of new techniques and technology prompted us to evaluate more recently other alternative and minimally invasive methods of relieving a UPJ obstruction. We noted that radial balloon dilators had been used successfully to dilate vessels and other hollow viscera. The recent availability of the 8-atmosphere 3.8 Fr balloon dilator prompted us to evaluate its role in the UPJ obstruction since this catheter is small enough to be passed through a neonatal ureter in a retrograde fashion. We have now performed 14 retrograde balloon dilatations for UPJ obstruction and have completed postoperative evaluations in 10 patients. The early results indicate that 70% of our patients treated by a single dilatation have been relieved of obstruction and we believe that this technique holds some promise for the treatment of UPJ obstruction in neonates and infants.

The gold standard remains dismembered pyeloplasty, however, and confidence with the laparoscopic approach to the kidney prompted us to attempt this laparoscopically. We have now attempted six transperitoneal laparoscopic dismembered pyeloplasties. The first attempt was converted to a conventional open procedure because the UPJ was completely stuck to scar tissue from previous surgery.

We have successfully performed five dismembered pyeloplasties totally by the laparoscopic route in children. Four of these were for primary UPJ obstruction and one was for a failed endopyelotomy. The average age of these patients was seven years, four months (with a range of two years, seven months to nine years, three months). The average operating time was 116 minutes (range of 90 minutes to 160 minutes). We have only performed post-operative evaluation in two of these patients at six months and have demonstrated relief of obstruction on the DTPA renography in both patients. The other three are awaiting evaluation and the results will be reported in due course.

Laparoscopic dismembered pyeloplasty is technically a very challenging operation, the most difficult aspect being intracorporeal suturing. Our early experience with this operation suggests that correct positioning of instrument trocars is critical to facilitate the intracorporeal suturing.

The procedure is performed via an intraperitoneal route, and the anastomosis is performed with an intracorporeal continuous 5/0 monofilament absorbable suture. The posterior anastomosis should be performed first and we have found it easiest to perform this without a stent in place. A double pigtailed stent is inserted after completion of the back layer by passing a long teflon needle through the abdominal wall into distal ureter, and passing the guide wire antegradely into the bladder. The pigtailed catheter can then be slid over the guide with relative ease. No perinephric drain is used, since any urinary leak will only drain freely into the abdominal cavity, this being an intraperitoneal procedure.

All patients with one exception stayed overnight in hospital. This patient developed a subcutaneous haematoma from a trocar puncture and remained in hospital for four days.

Our early impression is that laparoscopic dismembered pyeloplasty can be performed in about 90 minutes once the surgeon is through the learning curve. It may be the procedure of choice for the future as the results should not be any different from open dismembered pyeloplasty. The main difficulty would be to suture in a confined space, and it would therefore be technically extremely difficult to perform a suture anastomosis in a neonate. However our experience suggests that it is technically just as easy in a two-year-old infant as it would be in older children.

These new developments could foretell a change in our future management of UPJ obstruction. My current protocol is to perform retrograde balloon dilatation in infants and to offer laparoscopic dismembered pyeloplasty in children over the age of two. Endopyelotomy is reserved for those with renal calculi and associated UPJ obstruction or those with failed previous open pyeloplasty. We have not addressed the issue of failed retrograde balloon dilatation in infants, but will consider repeating the dilatation in future.

The era of minimally invasive treatment for UPJ obstruction is here. However this requires combined knowledge and skills in intraluminal endoscopy, laparoscopic surgery and interventional radiology, each of which have a steep learning curve. For that reason, it will be some time before the minimally invasive management of UPJ obstruction becomes a routine practice.

MR. ROBERT FOWLER, FRACS
Department of Surgery, Royal Children's Hospital, Melbourne, Australia

Evolving Role of Laparoscopy in the Management of High Undescended Testes: A Critical Review

High undescended testes (UDTs) present special problems for which the established surgical options are still unsatisfactory. The available options include conventional transinguinal orchidopexy (TIO) with extension of the incision as necessary; multiple-stage orchidopexy (MSO) and testicular vessel division (TVD) with attempted preservation of collateral supply. More recent options include autotransplantation of the testis (AT), and staging of TVD, either by the inguinal or laparoscopic route.

By referencing relevant publications appearing in the past few years (1989-1994) to what has gone before, several key issues emerge notably, the place of preoperative investigations, the role of laparoscopy, and whether surgical planning should be by preemption or default.

Conventionally, exploration has begun with a standard inguinal incision, extending extraperitoneally and intraperitoneally as necessary. However, extensive cord dissection in the canal or retroperitoneum must seriously prejudice the prospects for other available options Unless these alternative techniques yield worse results than those of conventional TIO, then a preferable strategy is to base the choice of options on preoperative knowledge of the location of the testis and the configuration of the vas and vessels. This is best achieved by laparoscopy.

Some surgeons still favour primary surgical exploration in preference to any preoperative investigations, including laparoscopy (Ferro et al, 1992; Ilazebroek and Molenaar, 1992; Zerella and McGill, 1993), but this is the policy of planning by default. For pre-emptive planning to succeed, laparoscopy is essential. It is by far the most informative investigation, establishing the presence or absence of an intraabdominal testis and any associated abnormalities, the configuration of the vas, and the length of the testicular vascular pedicle. Laparoscopic orchidectomy can be performed if an atrophic, hypoplastic or grossly dysplastic testis is located and immediate blind exploration avoided if no testis or cord structures are found. If no intraabdominal testis is found, but testicular vessels are seen exiting through the internal ring, with or without a vas, then inguinal exploration for a testis or remnant can follow immediately. If testicular vessels are nowhere to be found, then an unnecessary inguinal exploration can be avoided. If mobilization by staged TVD is chosen, the initial vessel interruption can be done at laparoscopy (Bloom, 1991; Waldschmidt and Schier, 1991) rather than by open operation. When TVD is contraindicated by an unusually short vas, or vasal anomalies, then AT can be chosen. In order to make the best pre-emptive choice of surgical options we also need to know the probabilities of success or failure by any of the available techniques. Detailed discussion of individual techniques or papers lies outside the scope of this commentary, so that only the main conclusions drawn from this critical reappraisal are offered, giving references to relevant studies as seems appropriate.

The limitations of conventional TIO (Saw et al, 1992), of the extended suprainguinal approach (Youngson and Jones, ... and of MSO (Zer et al, 1975; Redman, 1977) are ... umented. These methods seldom achieve satisfactory scrotal placement in more than 80% of impalpable testes and usually achieve less.

Although TVD has had only 50-75% success in some hands, Levitt reported an average success rate of 82% in nine series (Levitt et al, 1979), and two large recent series, with strict selection based on a positive "bleeding test," had success rates of 89% (Kogan et al, 1989) and 96% (Waldschmidt and Schier, 1991). Essentials for success have previously been detailed (F&S; Kogan).

An important modification of TVD is staging, with initial ...cing or division of the testicular vessels by open ...eration (Engel, 1972; Ransley et al, 1984) or by laparoscopy (Bloom, 1991), with TIO as a secondary procedure after six to 12 months. By allowing more time for collaterals to develop, staging seems likely to give greater success in general hands than unmodified TVD. For open staged TVD, success rates thus far have varied from 65% (Lawson et al, 1991) to 81% (Boddy et al, 1991), 91% (Elder, 1992) and 100% (Ransley et al, 1984).

Reports of laparoscopic staging (Andze et al, 1990; Wilson-Storey and McKinnon, 1992; Bloom, 1991; W&S, 1991; Bogaert et al, 1993) are meager thus far, but their combined early success rate of 18 of 20 testes (90%) is encouraging and there is no reason to anticipate that the laparoscopic technique will be less effective than open ...ging. Visible increases in collateral supply certainly ...cur, and of special interest is the development of gubernacular collaterals following laparoscopic TVD in infants (Waldschmidt and Schier, 1991). Post-TVD growth of the testis has also been observed (W&S). The earlier the procedure is performed, the better may be the chance of exploiting this previously unrecognized avenue of supply. If wider experience supports these early favorable results, then endoscopic TVD, with its obvious advantage of avoiding one open operative procedure, seems likely to supplant open staging as the preferred technique for TVD.

Microvascular AT has success rates ranging between 54-100% (O'Brien et al, 1983; Harrison et al, 1991), but mostly in the range of 83 to 88% (Wacksman et al, 1982; Garibyan et al, 1984; Frey and Bianchi, 1989; Boddy et al, 1991). AT chosen pre-emptively for impalpable testes had the highest success rate (Harrison et al, 1991). That the testis can remain viable despite anastomotic occlusion, if the vasal collateral supply is adequate (Bianchi, 1984), makes reported success uncertain, unless anastomotic occlusion always is recognized.

From the preceding brief apppraisal there is no clear-cut indication favoring any one technique over another. For intraabdominal testes, the results of highly selective and staged TVD are both closely comparable to those of AT, with poor results for all of these techniques in some series. Accordingly, staged TVD remains a justifiable alternative to AT unless vasal anomalies or other indications of deficient collateral supply are present (eg, testes already subjected to radical retroperitoneal dissection). AT is then indicated If laparoscopic staging continues to yield good results, it is likely to receive wider application than AT.

Since the results of staged TVD or AT are at least as good as, or better than, those obtainable by conventional TIO or MSO, planning can now be pre-emptive instead of by default, based on laparoscopic information as to the location of the testis, and the configuration of the vas and vessels. Early results of staged laparoscopic TVD are encouraging, making this an acceptable alternative to other established options. Therapeutic laparoscopic procedures are still evolving, with laparoscopic orchidectomy already established for manifestly defective testes.

More satisfactory assessment can be offered only after more data are available as to the postpubertal size and function of the testes, and the selection criteria adopted for each technique. A recent study (Saw et al, 1992), highlights the problems of uniform classification and selection since a quarter of "impalpable" testes were found at operation in the superficial inguinal pouch, a third in the canal, and a third in the abdomen. Expectations for salvage by any of these methods should not run too high, in view of the 5% postoperative atrophy rate after TIO even for palpable testes (Wilson-Storey et al, 1990), and the 38-87% incidence of vasal and epididymal abnormalities affecting the growth and fertility of most cryptorchid testes (Koff and Scaletsky, 1990).

YOUR RESPONSE

We'd like your comments on the subject of this and other issues of this publication. Please send them to Richard M. Ehrlich, MD, 100 UCLA Medical Plaza, Suite 690, Los Angeles, CA 90024.

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From

"Recent advances in Endourology"

editors: Yoshida et al

Springer- Verlag

(in print)

Pediatric Minimally Invasive Surgery

Hock-Lim Tan

Summary. Although pediatric minimally invasive surgery is still in its infancy, there is no doubt that it is gaining acceptance as an alternative method of treating many diseases that in the past required open surgery. It is having a rapidly expanding role, and there is increasing demand by patients to be treated by less invasive methods. The future of surgery must now rest in our ability to reduce the trauma inflicted on our patients.

Key words: Minimally Invasive Surgery, Pediatric laparoscopy, Pediatric endoscopy, Pediatric endourology

Introduction

Many advances have been made in the past decade allowing for minimally invasive methods of managing complex pathology. In pediatric urology, however, the spectrum of pathology is different from that seen in adults, and this makes it difficult, if not impossible, to employ any single treatment modality to manage many of the conditions seen in children. This chapter serves to highlight some of the differences in pathology and discusses some of the minimally invasive methods for managing these problems.

To begin with, many pediatric urological problems are congenital, functional, or self-limiting. Dysfunctional conditions such as neuropathic bladder may lead to bladder neck problems requiring bladder neck surgery, which can reality be done by periurethral injection. Conditions such as antenatally diagnosed hydronephrosis, multicystic dysplastic kidneys, and vesicoureteral reflux are often self-resolving, and the management of these conditions depends on whether surgery is required at all in the first place.

One may also need to modify many forms of treatment to avoid special problems in children, such as damage to the lung during extracorporeal shock-wave lithotripsy (ESWL). Although many forms of treatment have been shown to be safe in adults, the long-term results of treatment are still unknown, and we have to remain cautious about the use of surgical implants such Teflon for the endoscopic treatment of vesicoureteral reflux.

Department of Surgery, The Chinese University of Hong Kong, Prince of Wales Hospital, Shatin N.T., Hong Kong S.A.R.

Despite these special problems, many conditions are amenable to treatment by minimally invasive methods, which will be discussed in this chapter.

Management of Urinary Calculi in Children

Urinary calculi are relatively uncommon in children, but the increasing use of bladder augmentation for neuropathic bladders will probably result in an increased incidence of infective bladder stones and possibly upper tract calculi as well.

Upper tract stones in children comprise less than 1% of all calculi seen today [1]. Unlike adults, in whom the majority of urinary calculi are idiopathic, a significant proportion of renal calculi in children have an underlying etiology, the commonest being infection, which is responsible for about 40% of renal calculi seen in our series. Concomitant abnormalities, such as an obstruction, neuropathic bladder, or reflux, will often complicate the management of these stones. There is also a higher incidence of metabolic diseases such as cystinuria in children. Although some authors have reported a high degree of success with ESWL [2,3], others, such as Losty et al. [4] and ourselves, have found that only about 25% of all our pediatric calculi were suitable for treatment by ESWL. The majority in our series required percutaneous nephrolithotripsy (PCNL), and the majority in the series published by Losty et al. required open surgery.

Despite this, patients presenting with a small upper tract stone without obstruction can be managed by ESWL alone, but special precautions must be taken to prevent shock-wave damage to the lungs in young children. Polystyrene foam wrapped around the chest wall usually suffices [5], but this may reduce the efficacy of ESWL by reducing the overall width of the shock wave. There are also a significant number of children who require more than one ESWL session for stone clearance.

We have employed ESWL as monotherapy in the management of upper tract stones without significant complications, although others have reported hematuria, colic, and fever [5] in up to 10% of patients undergoing ESWL alone. Although the long-term effects of ESWL are still largely unknown, Lottmann et al. have reported DMSA scan evidence of parenchymal damage 6 months after ESWL in children [6].

Children with staghorn calculi or stones >2 cm in diameter should be treated with combined therapy consisting of PCNL to reduce stone bulk, followed by ESWL, if appropriate.

Percutaneous Nephroscopic Procedures

PCNL is safe and effective in children [7–10], although experience with this modality remains limited. We have employed PCNL for over 10 years, the youngest patient to date being a 16-week-old infant with an incomplete cystine staghorn calculus. Even though PCNL is safe, there are several important factors one has to take into consideration when performing PCNL in children to ensure that it can be performed with safety.

Small children are at particular risk of hypothermia, especially if large volumes of fluid are used for irrigation during PCNL, as is often the case. It is very important therefore when performing PCNL in children to ensure that the extremities and all other body parts are wrapped in cotton wool and the child is protected with a space blanket to minimize heat loss (Fig. 1). Although warming blankets are efficient, their

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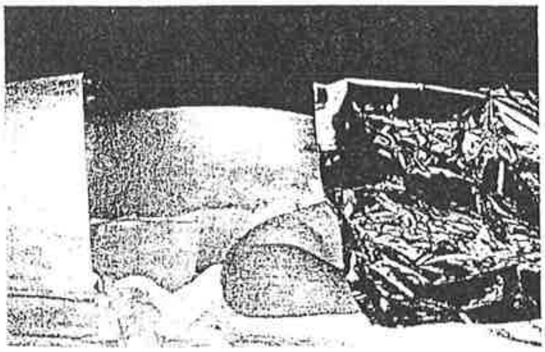

FIG. 1. Small infant completely insulated by wrapping all unexposed areas with cotton wool and space blanket

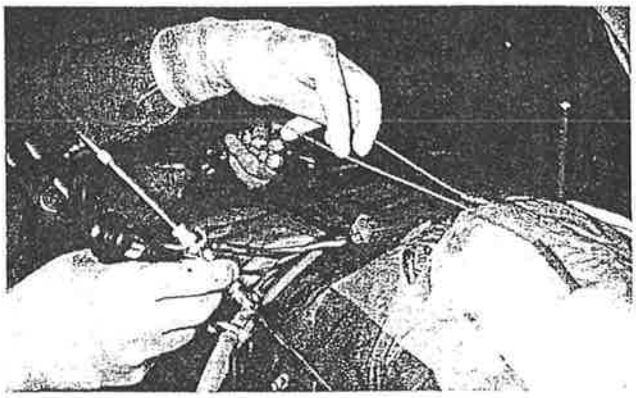

FIG. 2. Disposable neurosurgical incise drape keeping patient completely dry

use may interfere with the imaging of the upper tract during the procedure, and it is important to check this with a quick screen with the image intensifier before the patient is completely covered. If it is necessary to use a warming blanket, we recommend that it be placed on the upper part of the body.

We have found that the most efficient method of maintaining the child's body temperature is to keep the child as dry as possible. A disposable neurosurgical incise drape that has a large water bag to contain the runoff serves this purpose extremely well (Fig. 2).

Other important factors in the prevention of hypothermia are to ensure that all irrigating fluid is prewarmed (we have used up to 10 l of fluid for some procedures) and to limit the operating time for PCNL. This is best accomplished by reducing the down time spent waiting for instruments, radiography, or a new bag of fluid, which requires considerable planning and training of an efficient team of operating room nurses and technicians.

The collecting system in infants is considerably smaller than in adults. This often means that only a small length of guidewire can be introduced into the collecting system, which makes it easier to dislodge the guide during the puncture and creation of the tract. We therefore try to manipulate the guidewire into the ureter or even into

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the bladder to reduce the chance of accidental dislodgment during the creation of the tract. We have found that this is best done with the latest generation of guidewires with hydrophilic coatings, although special care must be taken to ensure that they do not become dislodged, because they are extremely slippery.

The small size of the collecting system also means that it is easier for the dilators to be dislodged during dilatation of the tract. An infant's kidney is extremely mobile, which also increases the risk of dislodgment. Because of this, we do not recommend the use of serial telescopic dilators, which are stepped and can dislodge from a small collecting system when a larger one is introduced over the smaller dilator. The same problem exists with the Amplatz serial dilators, where there is risk of dislodgment during the interchange. Balloon dilators have a tapered end that tends to slip out of a small collecting system unless one can introduce a substantial length into the collecting system.

Another consideration in performing PCNL in children is the risk of bleeding because of the relatively small blood volume. Even a small amount of bleeding into the collecting system will make endoscopy difficult, since all the blood has to be sucked out before PCNL is performed. Hence, it is important to reduce blood loss as much as possible. We have found the bleeding usually occurs during the interchange of dilators. We found that a single-stage incremental dilator [11] with a specially modified Amplatz dilator (Cook Urology) with a sharpened end somewhat like a pencil causes less bleeding and trauma, and this is our preferred method of dilating a tract.

Because most infant kidneys are extremely mobile, they tend to be pushed away from an advancing puncture needle or dilator. It is important to bolster the kidney adequately with a sponge placed underneath the patient to stabilize the kidney. We also prefer to puncture the lower-pole calix and create a tract below the 12th rib. Because infant breathing is primarily diaphragmatic, and the lung can extend quite low, especially when a child is being ventilated, there is an increased of pneumothorax if the puncture is made above the 12th rib.

Surgical Hardware for PCNL

Even though paediatric nephroscopes are available, we have found that these are still too big for infants, being 18F in diameter and requiring at least a 24F Amplatz sheath, which increases the risk of splitting a small kidney. We prefer to deploy a 9.5F offset lens operating cystoscope with a 5F operating channel. This instrument makes an excellent infant nephroscope and can be passed through a 14F Amplatz. The 5F single operating channel is also sufficient to perform any endoscopic manipulation and allows the ureteroscopic ultrasonic probe, lithoclast, or holmium laser fiber to be passed with ease.

By and large, the most serious complication to avoid is fluid overload when performing PCNL in children, as one can often use up to 10l of irrigation fluid during a single PCNL session, and it is impossible to accurately monitor how much fluid is absorbed during PCNL. However, the risk of massive fluid overload can be reduced by using the open Amplatz method and by keeping the head of pressure of the irrigating fluid as low as possible by not hanging the fluid bags too high. PCNL should be abandoned *immediately* if extravasation is detected. It is far safer to leave the child with a nephrostomy and to return a few days later to complete the procedure than to risk a massive fluid overload.

Other Safety Considerations

Although we prefer to perform PCNL as a single-stage procedure, performing the renal puncture ourselves, this requires practice in young infants and there is definitely a learning curve involved. When starting off, therefore, it may be safer for the interventional radiologist to establish a percutaneous nephrostomy and to allow this to mature before proceeding to PCNL.

Ureteropelvic Junction Obstruction

Ureteropelvic junction (UPJ) obstruction remains the commonest obstructive uropathy in children. Although the majority of cases of antenatally diagnosed hydronephrosis resolve, a significant number of patients have UPJ obstruction that requires surgical correction. Although the gold standard continues to be Anderson-Hynes dismembered pyeloplasty, several minimally invasive options for the management of UPJ obstruction in children are available today.

Endopyelotomy

Endopyelotomy or pyelolysis is well reported in adults, but there are only few reports of endopyelotomy in children to date [12–15]. A success rate of about 80% has been reported by most authors, comparable to results achievable in adult series. Our technique is similar to that described for adult series and involves passing a retrograde 5F angiographic catheter via cystoscopy into the renal pelvis. The patient is then turned into the prone position, and a percutaneous nephrostomy is established by puncturing a lower-pole calix.

This is then dilated to accommodate a 14F Amplatz sheath, and nephroscopy is performed to locate the tip of the previously inserted 5F angiographic catheter. A guidewire is then passed through the angiographic catheter, retrieved from within the renal pelvis, and exteriorized as a universal guidewire, which cannot then be accidentally dislodged. A second guide is then inserted through the UPJ via the nephroscope, allowing the UPJ to be splayed open by advancing the cold knife between the two guides, making for relatively easy incision of the UPJ. A full-thickness incision is made in a posterolateral position extending from the pelvis into the normal proximal ureter.

An external nephrostomy stent is then inserted into the upper ureter, the proximal end of which is exteriorized and left to drain freely until the urine is clear before it is spigotted. The nephrostomy is removed 6 weeks after endopyelotomy, and a nephrostogram is performed to demonstrate patency of the UPJ.

The main disadvantage of endopyelotomy is the need for the patient to wear an external nephrostomy stent for 6 weeks. We have found that children do not tolerate these well, and it is not possible to insert an internal 8F double J stent in young infants because of the narrowness of the UV junction. Endopyelotomy is also unsuitable for young infants because it is not possible to use a sufficiently large stent.

Clayman has described the use of antegrade accusice endopyelotomy as being effective in adults. Although accucise endopyelotomy has been reported in two children [16], this technique is not applicable to young children because of the large

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caliber of the accucise catheter. A 5F accucise catheter has recently become available, but the balloon enlarges to 10F diameter and the shaft of the catheter tapers to 8F diameter, making it still largely unsuitable for use in small children at the present time.

Although the results with endopyelotomy are not as good as those with dismembered pyeloplasty, we believe that there is still an indication for endopyelotomy in selected cases, especially after failed open pyeloplasty [13,14], if there is an associated renal calculus requiring PCNL or in children with a nephrostomy previously inserted for drainage.

Retrograde Balloon Dilatation

Retrograde balloon dilatation as the primary treatment of UPJ obstruction has also been described by us [17] and by Doraiswamy [18] as a alternative procedure. The procedure can be performed as an outpatient procedure. It involves performing a retrograde pyelogram under image intensifier control and then passing a guidewire into the renal pelvis, followed by a 5F or 3.8F PTCA catheter to dilate the UPJ. In our cases we have encountered a very tight hourglass-like stricture, which we have attempted to dilate. (accompanying figures). A 5F internal double J stent is then inserted to stent the UPJ for about 6 weeks.

This procedure was attempted in 16 patients, but we could successfully dilate the UPJ in only 10. Of those in whom dilatation was possible, improvement in drainage was seen in 7, a 70% success rate.

There are limitations to retrograde balloon dilatation, with a high technical failure rate, since we could not pass the balloon catheter through the UPJ in four patients. We were unable to dilate the stenosis in two others because of insufficient pressure generated by the balloons with a burst pressure of 8 atmospheres. Notwithstanding this, one has to reevaluate the possibility of performing retrograde radial balloon dilatation when balloon dilators with much higher burst pressures become available.

Laparoscopic Anderson-Hynes Dismembered Pyeloplasty

There are very few reports of laparoscopic Anderson-Hynes dismembered pyeloplasty to date [19–22], and even fewer in children [23,24]. Most report that this is an extremely difficult operation, with average operating times ranging from 120 min (using the endostitch suturing machine) to 530 min. We have now performed 18 Anderson-Hynes dismembered pyeloplasties via a transperitoneal route and describe the technique below.

The patient is positioned at the edge of the operating table as illustrated and is well secured with elastoplast dressing (Fig. 3). We use only one monitor, and all operators stand on the same side (Fig. 4), which is important for correct hand-eye coordination.

The kidney is approached via a transperitoneal route by reflecting the colon off Gerota's fascia. This usually requires very little intraperitoneal mobilization, as the kidney is always dilated and easy to identify.

Unlike others who advocate passing a retrograde ureteral or Fogarty catheter before pyeloplasty, we do not find this necessary. It is easy to identify the UPJ laparoscopically by commencing dissection in the renal sinus to identify the pelvis and then following it medially until the leash of gonadal vessels is found. The UPJ is then

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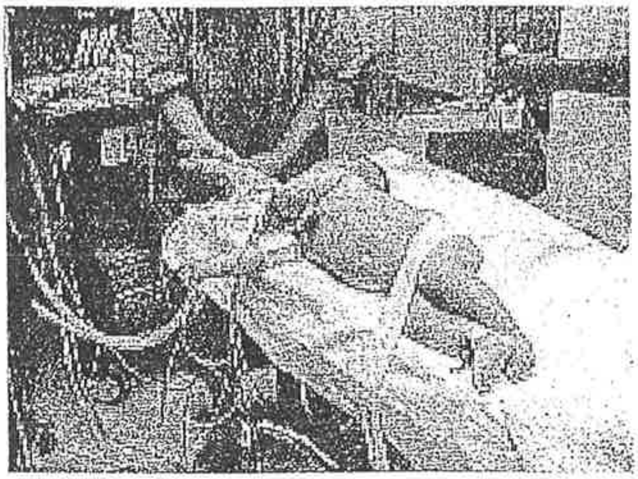

FIG. 3. Patient position for laparoscopic pyeloplasty

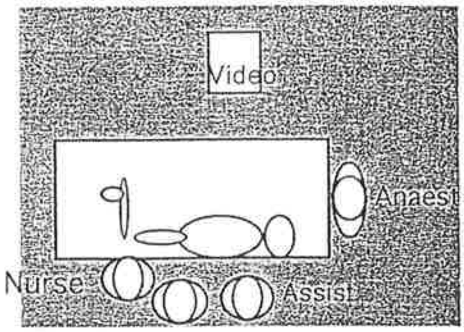

FIG. 4. Floor plan for laparoscopic dismembered pyeloplasty. Note that only one monitor is required, and the surgeon, assistant, and operating room nurse stand on the same side

usually identified by a lifting motion, and the proximal ureter can then be mobilized (Fig. 5).

Most authors report that endosuturing is extremely difficult. However, we have refined the technique of endosuturing and simplified it by stabilizing the anastomosis with a trancutaneous "hitch stitchi" on the renal pelvis. We believe that this hitch stitch is all-important in facilitating fine endosuturing (Fig. 6).

The pelvis is opened above the UPJ (Fig. 7) and the ureter is spatulated (Fig. 8a–c) before the UPJ is discarded. The anastomosis is completed with continuous 6/0 monofilament absorbable sutures, starting at the angle of the spatulated ureter, anastomosing this to the most dependent part of the renal pelvis (Fig. 9a,b). The posterior anastomosis is completed first by running this suture up toward the renal pelvis (Fig. 10).

On completion of the posterior layer, a 19F Teflon-coated needle is inserted near the subcostal margin, and a guidewire is inserted through this into the proximal ureter and passed into the bladder. The Teflon needle is then removed, and a 5F or 3.8F double J catheter is inserted into the bladder (Fig. 11).

The guidewire is then removed and the proximal end is inserted into the renal pelvis. The anterior anastomosis is then completed by running the suture from the

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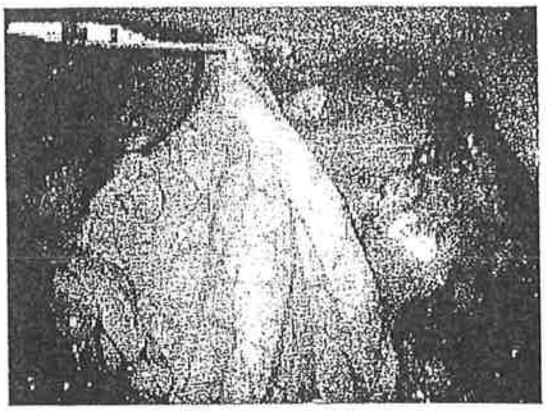

FIG. 5. UPJ exposed by lifting action after opening Gerota's fascia

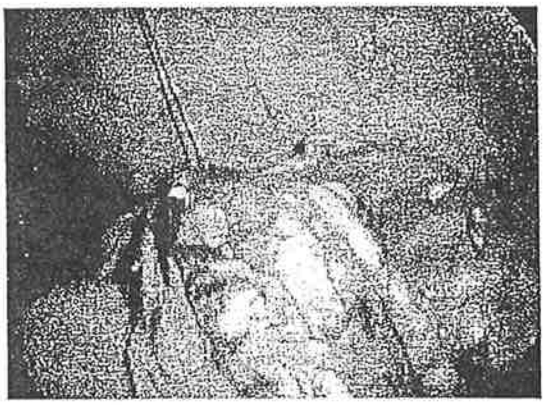

FIG. 6. Transabdominal hitch stitch is used to stabilize UPJ

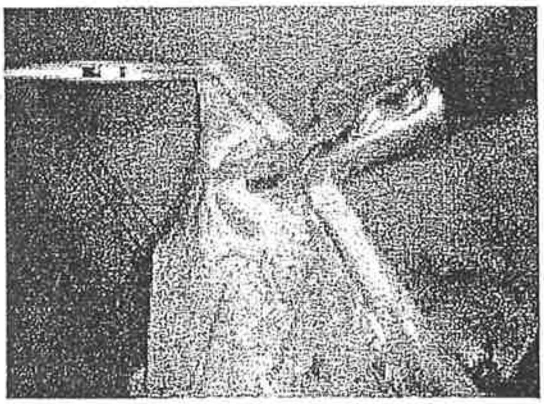

FIG. 7. Pyelotomy performed with sharp scissors

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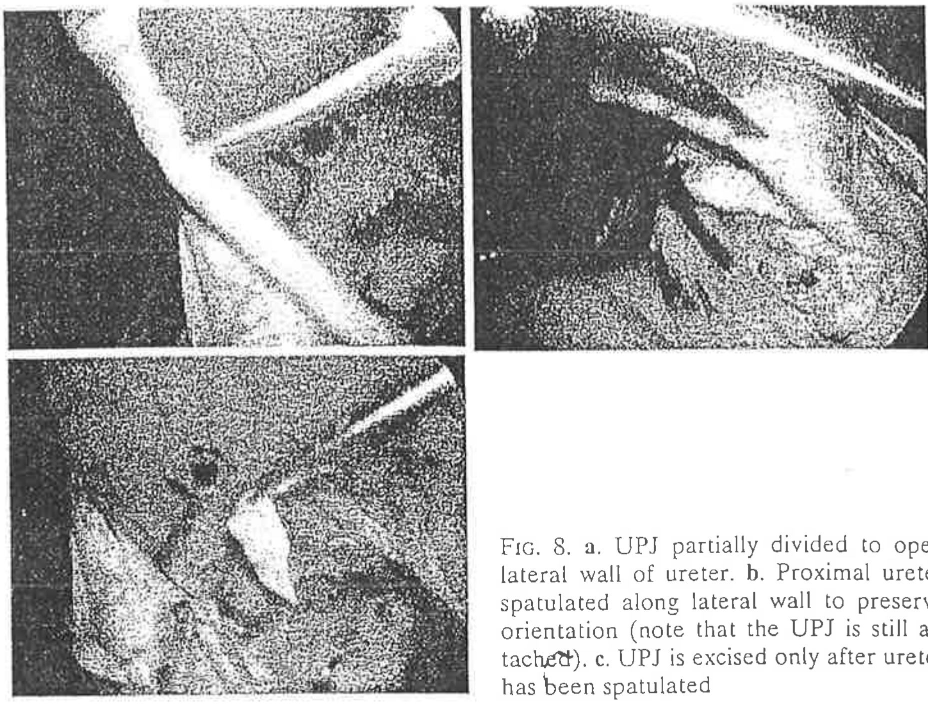
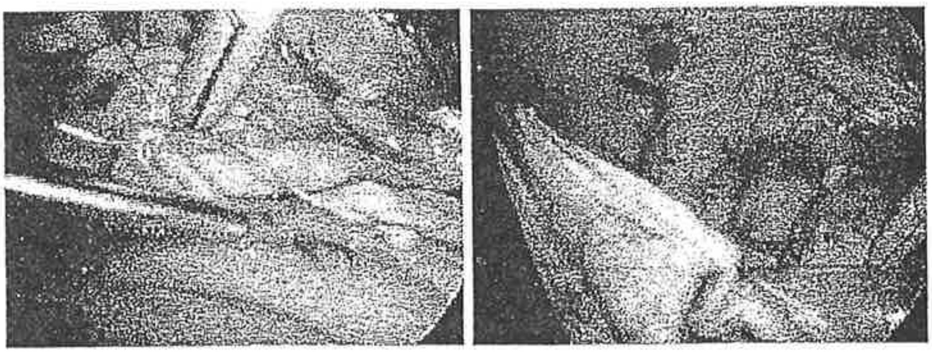


a b c

FIG. 8. a. UPJ partially divided to open lateral wall of ureter. b. Proximal ureter spatulated along lateral wall to preserve orientation (note that the UPJ is still attached). c. UPJ is excised only after ureter has been spatulated



a b

FIG. 9. a. First anastomotic suture is placed at angle of spatulated ureter. b. Ureter resutured to most dependent part of renal pelvis

pyelotomy toward the most dependent part of the anastomosis (Fig. 12). The hitch stitch is then removed, and the kidney is returned to its renal bed.

We do not use a perinephric wound drain, as the placement of a double J stent prevents urinary leak, and even should such a leak occur, the drain would not prevent intraperitoneal leakage.

The average operating time for the pyeloplasties in our series was 89 min, well within the operating time for conventional open pyeloplasties, making it a far more acceptable alternative.

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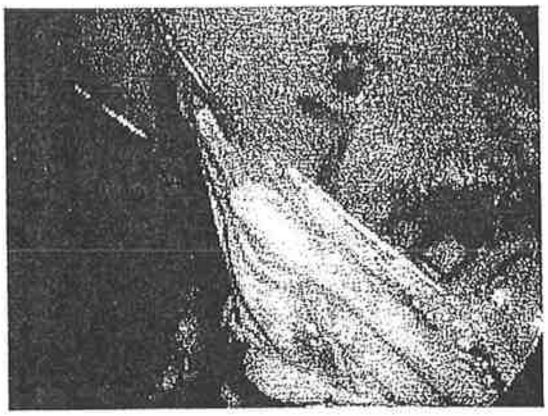

FIG. 10. Posterior anastomosis completed

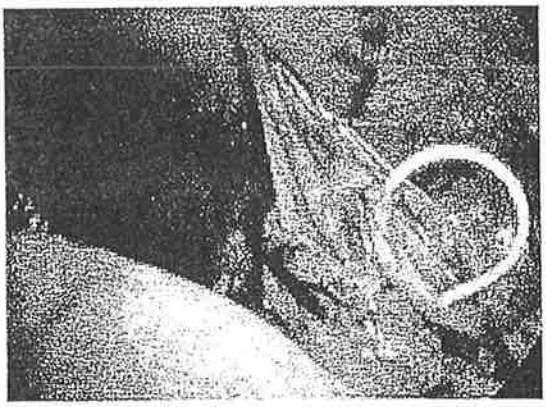

FIG. 11. Double J stent in situ

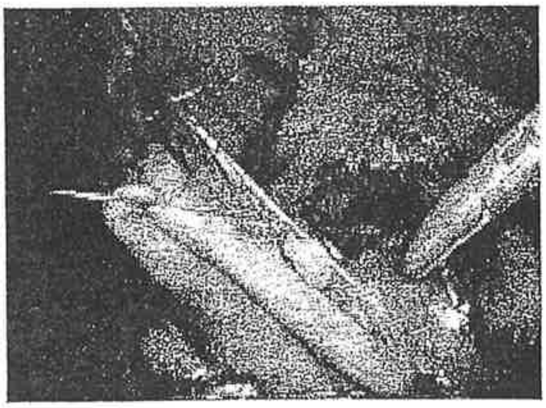

FIG. 12. Completed anastomosis

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Postoperative evaluation has now been completed in 16 of the 18 patients we have operated on, and relief of obstruction has been demonstrated in 14, giving a success rate of 87%, which approaches that for conventional open pyeloplasties. The two failures were in 3-month-old infants, where difficulties were encountered with endosuturing because of the small size of the ureter. The size of the ureter also created difficulties with insertion of the double J stent. Because of these technical difficulties, we currently do not recommend laparoscopic Anderson-Hynes dismembered pyeloplasty in infants less than 6 months old.

Although the operation is difficult to master, it is well within the grasp of any laparoscopic surgeon adept at intracorporeal suturing. Several endoscopic maneuvers and shortcuts have been developed to greatly facilitate this operation and to reduce the operating time to one comparable to that for an open pyeloplasty. However, these shortcuts are difficult to describe, and it is best to witness the operation itself firsthand to appreciate them.

Nephrectomy

Like most forms of endoscopic surgery, laparoscopic nephrectomy was developed in adult patients before being adopted by pediatric urologists. Laparoscopic nephrectomy was first described by Clayman et al. in adults [25], and the first report of nephrectomy in children was not until 2 years later [26,27]. Even though there was some initial reluctance to adopt laparoscopy for pediatric upper tract abnormalities, it is in fact an ideal approach to the upper tract in children, as most of the conditions we are dealing with in children are benign and lend themselves well to laparoscopic nephrectomy.

Although multicystic dysplastic kidneys are generally treated conservatively, it is generally accepted that a persistent multicystic kidney should be removed, particularly when multicystic dysplastic kidneys are among the easiest to excise laparoscopically. Much of the opposition to nephrectomy for multicystic dysplastic kidneys occurs because conventional open nephrectomy involves an extensive exposure. However, if it can be demonstrated that laparoscopic nephrectomy is indeed an easy, minimally invasive option, it is likely that in time, a more aggressive approach to the management of multicystic dysplastic kidneys will be adopted.

Laparoscopic nephrectomy for end-stage reflux or hydronephrotic kidneys is more difficult than that for multicystic dysplastic kidneys, particularly in the face of previous episodes of infection, when the kidney is often surrounded by dense perinephric fibrosis. Giant hydronephrotic kidneys, however, can be removed quite easily without morcellation if they are emptied of fluid before removal.

Transperitoneal Nephrectomy

This is a relatively straightforward procedure in children. The patient is placed in a prone position at the edge of the operating table and firmly secured with an elastoplast dressing.

We prefer to make a 270° incision in the skin crease at the base of the umbilicus and use an open Hasson technique through a small transverse linea alba incision placed about 1–2 cm above the umbilical cicatrix. This linea alba incision can then be enlarged quite considerably for extraction of the kidney. Care must be taken when

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opening the peritoneum, as the child is in a lateral position and the risk of visceral injury is higher.

Gerota's fascia and the underlying kidney are quite easily exposed by dividing the lienocolic ligament and its counterpart on the right side. Colonic mobilization is greatly facilitated by the administration of a preoperative enema. It is easiest to identify the ureter just below Gerota's fascia and follow it up to the renal hilum, where the vessels can then be individually identified. We prefer to complete the vessel dissection before mobilizing the kidney from its bed, as we find that the kidney is too floppy otherwise and gets in the way of the dissection.

When partial nephrectomy is performed for a duplex system, it is especially important to identify the ureters first. The duplex ureters are easily separated from each other just below Gerota's fascia by a maneuver similar to that used to separate a hernial sac from its adjacent structures.

The ureters should then be followed into the renal sinus to display the anatomy. The most difficult part of laparoscopic partial anatomy is displaying the renal vasculature. If nephrectomy is performed for a nonfunctioning upper pole, this can be greatly facilitated by dividing the upper-pole ureter early, passing it behind the renal sinus to the upper pole, and using this for traction to display the vascular anatomy.

Retroperitoneal Nephrectomy

Retroperitoneal nephrectomy has also been reported in children [28,29]. The retroperitoneal space can be easily approached from the loin through a small Hasson-type incision. A retroperitoneal space can be created by either inflating a small balloon made from the finger of a rubber glove or by blunt telescope dissection, using the telescope to break down loose connective tissue.

Retroperitoneal nephrectomy is more technically challenging, as the space is somewhat less in a child and it is not possible to display surrounding anatomy such as the major vessels. Duodenal perforation has been reported with this procedure [30]. It is also more difficult to follow the ureter distally for nephroureterectomy.

The main advantage of retroperitoneal laparoscopic nephrectomy is that it is performed entirely in the retroperitoneum. However, transperitoneal nephrectomy involves very little intraperitoneal mobilization, and the risk of formation of adhesions is low.

It is probably safer to perform a transperitoneal laparoscopic nephrectomy. In patients who have had repeated attacks of pyelonephritis or in those who have had previous renal surgery, as it is much easier to identify the surrounding anatomy and the operating space is significantly larger, thus avoiding accidental trauma to surrounding organs, especially if significant adhesions are anticipated.

Laparoscopy for Undescended Testes and Varicocele

Although undescended testes are a common pediatric surgical problem, only a small number are truly impalpable, requiring laparoscopic evaluation. In spite of newer diagnostic modalities, laparoscopy remains the most accurate diagnostic tool for the location of impalpable testes [31], but this has to be combined with a careful EUA before laparoscopy, as an emergent testis lying within the inguinal canal can

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sometimes only be located under a GA. If a testis can be felt in the inguinal canal, it is just as easy to perform conventional orchidopexy rather than proceed to laparoscopy.

Laparoscopy is performed using three ports, with the telescope placed in the umbilicus and the other two instrument ports in each iliac fossa. It is easiest to stand on the contralateral side of the patient, with a single video monitor placed at the foot of the operating table.

The testis is usually identified near the internal ring. If it cannot be easily located, it is best to locate the vas first by searching in the pelvis and following it toward its blind end or the testis.

If a hernial sac is present, the telescope should be inserted into the sac to look for the testis. A conventional open orchidopexy can usually be performed if the testis is in the sac.

A vas entering an internal ring accompanied by a fine leash of vessels usually signifies the presence of a so-called vanishing testis. In this instance we proceed to a small groin incision to remove the small nubbin of testicular remnant that one usually finds in these cases. We would excise any intraperitoneal dysplastic testicular tissue if this is found at laparoscopy.

The staged Fowler-Stephens method of orchidopexy has found favor among many laparoscopic surgeons for the truly intraabdominal testis. The internal spermatic vessels are easily divided. The orchidopexy can also be performed entirely laparoscopically 6 months after the ligation of internal spermatic vessels.

Laparoscopic varicocele ligation is well reported and appears to have a lower recurrence rate than conventional open operation [31,32]. The indication for ligation of adolescent varicoceles, however, remains unclear. There is some consensus that laparoscopic varicocele ligation should only be performed in the pediatric age group if it is accompanied by symptoms or if the testis is not growing. Whether a varicocele left untreated in a child will cause long-term damage is still not established.

Laparoscopy for Pelvic Pathology

There is an increasing number of reports of the use of laparoscopy for the treatment of pelvic and adnexal pathology [33–35], such as in the management of ovarian cysts, gonadectomy, oopheropexy, and even cystoprostatectomy for tumor. We have found that the combination of laparoscopy, cystoscopy, and vaginoscopy offers much greater diagnostic accuracy for the staging and evaluation of pelvic tumors than any imaging modality.

References

1. Longo JA, Netto NR Jr (1995) Extracorporeal shock wave lithotripsy in children. Urology 46(4):550–552
2. Robert M, Drianno N, Guiter J, Averous M, Grasset [redacted] (1996) Childhood urolithiasis: urological management of upper tract calculi in the era of extracorporeal shock wave lithotripsy. Urol Int 57(2):72–76
3. Frick J, Sarica K, Kohle R, Kunit G (1991) Long-term follow-up after extracorporeal shock wave lithotripsy in children. Eur Urol 19(3):255–259

G

4. Losty P, Surana R, O'Donnell B (1993) Limitations of extracorporeal shock wave lithotripsy for urinary tract calculi in young children. J Pediatr Surg 28(8):1037–1039
5. Nazli O, Cal C, Ozyurt C, Gunaydin G, Cureklibatir I, Avcieri V, Erhan O (1998) Results of extracorporeal shock wave lithotripsy in the paediatric age group. Eur Urol 33(3):333–336
6. Lottmann H, Archambaud F, Helal B, Mercier-Pageyral ■■, Melin Y (1995) Extracorporeal shock wave lithotripsy in children. Study of the effectiveness and renal consequences in a series of eighteen children. Ann Urol 29(3):136–142
7. Mor Y, Elmasry YE, Kellett MJ, Duffy PG (1997) The role of percutaneous nephrolithotomy in the management of paediatric renal calculi. J Urol 158:1319–1321
8. Kurzrock EA, Huffman JL, Hardy BE, Fugelso P (1996) Endoscopic treatment of pediatric urolithiasis. J Pediatr Surg 31(10):1413–1416
9. Webb DR, Tan HL (1995) Intraluminal surgery of the upper tract Dialogues in Ped Urol
10. Callaway TW, Lingardh G, Basata S, Sylven M (1992) Percutaneous nephrolithotomy in children. J Urol 148:1067–1068
11. Travis DG, Tan HL, Webb DR (1991) Single incremental dilatation for percutaneous renal surgery: An experimental study. Br J Urol ■■:144–147
12. Tan HL, Najmaldin A, Webb DR (1993) Endopyelotomy for pelvi-ureteric junction obstruction in children. Eur Urol ■■:84–88
13. Faerber GJ, Ritchey ML, Bloom DA (1995) Percutaneous endopyelotomy in infants and young children after failed open pyeloplasty. J Urol 154(4):1495–1497
14. Capolicchio G, Homsy YL, Houle AM, Brzezinski A, Stein L, Elhilali MM (1997) Long-term results of percutaneous endopyelotomy in the treatment of children with failed open pyeloplasty. J Urol 158(4):1534–1537
15. Schenkman EM, Tarry WF (1998) Comparison of percutaneous endopyelotomy with open pyeloplasty for pediatric ureteropelvic junction obstruction. J Urol 159(3):1013–1015
16. Bolton DM, Bogaert GA, Mevorach RA, Kogan BA, Stoller ML (1994) Pediatric ureteropelvic junction obstruction treated with retrograde endopyelotomy. Urology 44(4):609–613
17. Tan HL, Roberts JP, Grattan-Smith D (1995) Retrograde balloon dilation of ureteropelvic obstructions in infants and children: early results. Urology 46(1):89–91
18. Doraiswamy NV (1994) Retrograde ureteroplasty using balloon dilatation in children with pelviureteric obstruction. J Pediatr Surg 29:937–940
19. Schuessler WW, Grune MT, Tecuanhuey ■■, Preminger GM (1993) Laparoscopic dismembered pyeloplasty. J Urol 150(6):1795–1799
20. Brunet P, Leroy J, Danjou P (1996) Eight cases of pyelo-ureteral junction syndrome treated by laparoscopic surgery. Chirurgie 121(6):415–417
21. Moore RG, Averch TD, Schulam PG, Adams JB, Chen RN, Kavoussi LR (1997) Laparoscopic pyeloplasty: experience with the initial 30 cases. J Urol 157(2):459–462
22. Janetschek G, Peschel R, Bartsch G (1996) Laparoscopic and retroperitoneoscopic kidney pyeloplasty. Urologe-Ausgabe 35(3):202–207
23. Peters CA, Schlussel RN, Retik AB (1995) Pediatric laparoscopic dismembered pyeloplasty case report. J Urol 153(6):1962–1965
24. Tan HL, Roberts JP (1996) Laparoscopic dismembered pyeloplasty in children: preliminary results. Br J Urol 77:909–913
25. Clayman RV, Kavoussi LR, Soper NJ, Dierks SM, Meretyk S, Darcy MD, Roemer FD, Fingleton ED, Thomson PG, Long SR (1991) Laparoscopic nephrectomy: initial case report. J Urol 146(2):278–282
26. Koyle MA, Woo HH, Kavoussi LR (1993) Laparoscopic nephrectomy in the first year of life. J Pediatr Surg 28(5):693–695

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27. Tan HL (1995) Laparoscopic nephrectomy and partial nephrectomy. Dialogues in Ped Urol 18(2)
28. Diamond DA, Price HM, McDougall EM, Bloom DA (1995) Retroperitoneal laparoscopic nephrectomy in children. J Urol 153(6):1966–1968
29. Kobashi KC, Chamberlin DA, Rajpoot D, Shanberg AM (1998) Retroperitoneal nephrectomy in children. J Urol 160:1142–1144
30. El-Ghoneimi A, Valla JS, Steyaert H, Aigrain Y (1998) Laparoscopic renal surgery via a retroperitoneal approach in children. J Urol 160:1138–1141
31. Fahlenkamp D, Winfield HN, Schonberger B, Mueller W, Loening SA (1997) Role of laparoscopy in pediatric urology. Eur Urol 32(1):75–84
32. Seibold J, Janetschek G, Barsch G (1996) Laparoscopic surgery in pediatric urology. Eur Urol 30(3):394–399
33. Heloury Y, Guiberteau V, Sagot P, Plattner V, Baron M, Rogez JM (1993) Laparoscopy in adnexal pathology in the child: a study of 28 cases. Eur J Pediatr Surg 3(2):75–78
34. Tan HL, Scorpio RJ, Hutson JM, Waters K, Leung S (1993) Laparoscopic ovariopexy for paediatric pelvic malignancies. Pediatr Surg Int 8:379–381
35. Tan HL, Hutson JM (1994) Case report: laparoscopically-assisted cysto-prostatectomy Min Inv Ther 3:207–210

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Conclusions

And other previously unpublished

Material on Paediatric Endosurgery

Publications from Laparoscopic workshops

Laparoscopic workshops remain a popular mode of learning laparoscopic surgery among paediatric surgeons, and experience in the past few years from running courses suggests that it is necessary to teach basic principles, even to those attending advanced workshops.

Aside from a curriculum which includes instruction on how to perform specific laparoscopic procedures such a appendicectomy, safety and the correct ergonomics is stressed.

These two articles are from course manuals which are compiled by myself for various workshops I attend as faculty or course director. These are regularly updated if I come across a new complication or "trick of the trade" in the literature.

These are from the first Paediatric Laparoscopic Workshop conducted in India in Conjunction with the 24th Annual congress of the Indian Association of Paediatric Surgeons, Coimbatore, October 1998

Complications of Laparoscopic Surgery

Hock Lim TAN

The true incidence of complications in paediatric laparoscopy is largely unknown as meaningful statistics are only becoming available. Gans in 1973 reported 300 cases of laparoscopy in children without complications. There is no doubt however, that as the practice of endoscopic surgery becomes more common that complications *will* occur. In this section the potential complications of laparoscopic surgery, their management and prevention, are discussed. The best management of complications is prevention, and this section will also dwell on this.

Incidence

Data from several large centers shows minor and major complication rates ranging from 1 to 4 percent, and 0.3 to 2.8 percent, respectively. A review of over 20,000 cases from collected series from 1951 through 1968 revealed a mortality rate of about 1:1000 cases or 0.1%. Several recent reviews showed a decrease of up to 20 fold with mortality rates ranging from 0.5 to 2 per 10,000 cases. These however are all adult gynecological laparoscopy, which is largely diagnostic and confined to the simplest operative procedures.

Complex laparoscopic procedures such as nephrectomy, fundoplications etc. have a potential for serious complications, and special considerations have also to be applied to children.

Kavoussi et al. assessed intraoperative and postoperative complications in the initial 372 patients undergoing laparoscopic pelvic lymph node dissection at 8 medical centers in North America in 1993. in 16 patients (0.4%), laparoscopic node dissection could not be completed due to local anatomical or technical difficulties. *Fourteen of these aborted procedures occurred during the initial 8 dissections* at each institution.

A total of 55 (15%) complications occurred, 14 noted intraoperatively and 41 in the postoperative period. These complications included: vascular injury (11), viscus injury (8), genito-urinary problems (10), functional / mechanical bowel obstruction (7), lower extremity deep venous thrombosis (5), infection / wound problems (5), lymph oedema (5), anaesthetic complications (2) and obturator nerve palsy (2). thirteen of these patients required open surgical intervention for the treatment of complications.

Peters in a nationwide questionnaire to 251 Paediatric Urologist in North America in 1996 received a response from 153 urologists. Of those responding, 75% reported having performed diagnostic or therapeutic laparoscopy but the average case load was only 19 cases per year. Complications were reported in 6% of cases, and by far the commonest complication was extra-peritoneal insufflation. The Veress needle usage was associated with significantly greater complication rate, and if pre-peritoneal insufflation was excluded from the calculations, the complication rate fell to 1.18%.

The strongest predictor of laparoscopic complication rate is the experience of the practitioner. When fewer than 20 cases were performed, the complication rate was 8.3%. In contrast, those that had performed more than 100 cases reported a complication rate of only 2.8%. *Most of the major complications occur during the learning curve* either in the form of inability to complete the operation, or visceral injuries. There is clearly no substitute for experience. A survey by Leo Phillips et al. in 1993 found a four times greater incidence of complications in laparoscopic surgeons who had performed fewer than 100 procedures, when compared with experienced laparoscopists, confirming Craig Peter's finding.

The most dangerous period for the patient therefore, is during the surgeons learning curve.

Under experts hands, laparoscopy is safe. Martine, Demarche et al. in Liege, Belgium (one of the leading centers in Europe) reports a mortality rate of 0.1% and morbidity of 2% during the 4 year period from June 1st 1988 to June 30th 1992.

Hypercarbia

CO2 insufflation results in hypercarbia through absorption and reduced tidal volume due to splinting of the diaphragm. It is essential that all patients are closely monitored, not only for the normal cardio-respiratory parameters but also for end tidal CO_2. The fact that young children rely on diaphragmatic breathing more than intercostal breathing increases their liability to this risk, and increasing the insufflation pressure to 10mmHg in a neonate will compromise the tidal volume by 30%. There is usually an immediate rise in end tidal CO_2 by 10mmHg from diaphragmatic splinting, and a second rise in level of end tidal CO_2 about 20 minutes into laparoscopy. This presumably is due to absorption of CO_2 from the peritoneum.

Cardiac Arrhythmias
Arrhythmias, including sinus bradycardia, AV dissociation, and nodal rhythms have been attributed to a vagal response secondary to abdominal distention and peritoneal irritation. A recent prospective study found a 14 percent incidence of arrhythmias during laparoscopy in adults. Atropine prior to insufflation may decrease the these vagal reactions. This risk may be related to too rapid an insufflation rate. One of our patient developed supra-ventricular tachycardia which reverted spontaneously with hyperventilation.

When arrhythmias occur, the abdomen should be desufflated and the patient hyperventilated. Drug therapy should be administered as indicated.

Note that most many high flow insufflators have a default setting of 1L/min. This default setting may be excessive in infants who may have a total abdominal volume of only 500ml unlike an adult abdomen which can accommodate 5L of CO_2. It is important that you chose an insufflator with a low default setting of 100ml/min. High flow is not so important in paediatrics.

Reduction in Tidal Volume
Mask anaesthesia is completely inappropriate for paediatric applications. Several deaths have been attributed to using mask anaesthesia. Endotracheal anaesthesia with paralysis and positive pressure ventilation *are mandatory* in paediatric laparoscopy even for short procedures. Mask anaesthesia may also cause gastric distention, increasing the risk of trocar perforation or aspiration pneumonia.

Avoid Nitrous Oxide in infants, as this leads to gaseous distention of the bowel and can compromise an already small abdominal cavity, making laparoscopy difficult.

Increasing intra-abdominal pressure beyond 10mm in an infant will increase splinting of the diaphragm and restrict ventilation. To avoid complications the insufflator should be checked before each operation; the intra-abdominal pressure should be set at 10mmHg in an infant under 10Kg, and 12 to 15 mmHg in the older children.

Complications of Pneumoperitoneum
Inability to create a pneumoperitoneum is responsible for more failed procedures than any other cause. Most adult laparoscopists use the Veress needle technique to create the pneumoperitoneum. *This blind technique has great potential for disastrous consequences* in paediatrics surgery particular in infants and young children, *and should be avoided*.

Anaesthetic Complications
Anaesthetic-related complications have been a major cause of mortality in gynaecological laparoscopic surgery. It is important for the anaesthetist to continuously monitor the patient in order to quickly recognise and treat problems as they arise. Careful positioning of the patient and padding, is required to avoid potential orthopaedic injuries or nerve palsies, although I suspect the incidence of nerve palsies will be somewhat less in children.

Potential complications reported in general anaesthesia for laparoscopic surgery include hypothermia, hypotension, esophageal intubation, gastro-oesophageal reflux, bronchospasm and narcotic overdose. A study from the Centre for Disease Control suggests that anaesthetic complications may account for approximately one third of the few deaths associated with laparoscopic tubal ligation.

There are several specific anaesthetic concerns pertaining to laparoscopy and each will be discussed.

Hypothermia
Paediatric patients are especially at risk from high flow insufflation. Because of the relatively small body mass, high flow insufflation will dissipate body heat rapidly as the temperature of the Carbon Dioxide leaving the insufflator is 20^{0} Celsius or less. It is best to keep gas flow rates low by minimising gas leaks from your instrument ports and port sites. The commonest cause of excessive gas leaks are worn washers or opened taps. Regular maintenance checks on all equipment especially taps and washers will minimise gas leaks.

Wrap the extremities of babies with cotton wool to minimise heat loss, use a warmer, avoid high flow and keep your patient dry.

Positioning the Patient
The position of the patient can impair ventilation or even increase the risk of aspiration. For example, positioning the patient into a steep Trendelenburg position increases the risk of aspiration and it may be necessary to insert a naso gastric tube to prevent this.

If you need to use image intensifier intra-operatively, check that the "C" arm of your II can be positioned under the area you wish to image, and that the warmer does not interfere with your imaging. It is best to run s spot check with the II before accepting the final patient position.

Veress needle
The Veress needle is dangerous to use in children. The water drop tests etc. sued to confirm correct Veress needle placement *are not necessarily reliable* because of the laxity of the peritoneal attachment to the overlying abdominal musculature. Pressure monitoring likewise during insufflation is not a reliable indicator that you are in the abdomen, because extraperitoneal insufflation will strip the peritoneum off its abdominal wall attachment with great ease in young infants.

Open laparoscopy was introduced by Hasson in 1971 and involves placing the primary cannula through a "mini-laparotomy" incision. A blunt-tipped trocar and cannula is inserted under direct vision to avoid inadvertent visceral or vascular injury. This is our recommended technique for laparoscopic access to the peritoneal cavity in children.

The Hasson open laparoscopy method is not without its complications, the most serious complication being inadvertent bowel perforation from adherent underlying bowel due to previous surgery. While it is the usual practice to use the umbilicus as the portal of entry, *this is not the only port*. I have often introduced the Hasson cannula at a site well away from previous surgical scars to avoid this complication.

Surgical Emphysema
Surgical emphysema in mostly due to incorrect (extraperitoneal) placement of the Veress needle, and avoidable by the Hasson method. It is readily detected as crepitus over the abdominal wall. No specific intervention is required, as it resolves quickly once the pneumoperitoneum is discontinued.

Localised emphysema is harmless. However, it is important to recognise that extensive subcutaneous emphysema may lead to pneumothorax, pneumo-mediastinum, and hypercarbia.

Tension Pneumothorax
Tension pneumothorax may arise in a number of ways. Extension of surgical emphysema into the mediastinum has already been discussed. The parietal pleura is particularly at risk while dissecting the hiatus during laparoscopic fundoplication. If the parietal pleura is breached, tension pneumothorax will rapidly ensue.

Transabdominal mediastinum surgery can also cause peribronchial tracking of the CO2 and pneumopericardium, and it is best to reduce insufflation pressures when dissecting the mediastinum via the abdominal route.

Undetected small diaphragmatic defects or weakness can lead to tension pneumothorax. Increased intra-abdominal pressure can also result in direct passage of gas along the great vessels hiatus into the mediastinum.

Insufflator malfunction, or prolonged high intra-abdominal pressure, may also lead to tension pneumothorax. This causes decreased venous return due to caval compression and can result in a decrease in cardiac output.

The laparoscopic procedure should be discontinued if crepitus is detected extending up the chest wall into the neck. Subcutaneous emphysema of the neck, face and chest wall, should also raise immediate concern that there may be a pneumothorax or pneumo-mediastinum, and a chest Xray should be obtained immediately, as it can be life threatening. Similarly, if the anaesthetist expresses concern about increasing difficulties with ventilation, pneumothorax should be suspected.

If tension pneumothorax develops, the procedure should be abandoned and the abdomen desufflated. The pneumothorax can be evacuated with a 16 gauge needle or a chest tube. Because the child will be intubated already, this should be all that is required. A pneumo-mediastinum can usually be managed conservatively with close observation.

Gas Embolism
Gas embolism is an infrequent but disastrous complication of laparoscopic surgery. Many of the early reported fatalities occurred with air. The much great solubility of CO2 has made it the insufflation agent of choice today. Nevertheless, carbon dioxide embolism can still occur.

Fatal gas emboli have been confirmed by radiologic and pathologic examination in a number of reports, and have been suspected as the cause of fatality in a large number of cases. The reported incidence in the gynaecological literature is small, *but* 1.7% of laparoscopic surgeons in a large survey have reported first hand experience.

The most likely cause is unrecognised placement of the Veress needle into a major vessel, although inadvertent small perforations in veins have also been reported as a cause of gas embolism, especially when high insufflation pressures are used.

The diagnosis of a gas embolism may be difficult as there is often no warning prior to sudden cardiovascular collapse. A "Millwheel" murmur over the pericardium has been classically described. Deep cyanosis of the hand and neck, consistent with inflow obstruction to the right heart, supports the diagnosis of gas embolus. Intra-operative end-tidal CO2 monitoring will detect early embolism, as an abrupt *decrease* in measured CO2 may be indicative of a gas embolus.

If gas embolism is suspected, insufflation should be discontinued and the abdomen deflated immediately. The patient should be turned onto the left lateral decubitus position with the head down, to allow the gas to rise to the apex of the right ventricle and retard entry into the pulmonary artery. Cardiopulmonary resuscitation should be instituted and a Central venous line placed to attempt aspiration of gas. Other successful treatment of gas embolism include the use of hyperbaric oxygen, direct aspiration of the gas through a percutaneously inserted aspiration needle, and cardiopulmonary bypass (ECMO).

It must be emphasized that *most cases of fatal gas embolism have been reported with incorrect Veress needle placement.* As this is preventable by the open Hasson technique, we cannot recommend the use of Veress needles in paediatric laparoscopic surgery.

Carbon Dioxide is a soluble gas, and a normal adult can tolerate a direct injection of about 400ml of CO2 directly into the intravascular space. Even though there are high flow insufflators available, insufflation should always be commenced at low volumes i.e. no more than 400ml/min in an adult, and correspondingly less in a child *especially if a blind Veress needle is used,* otherwise you may be faced with an irretrievable situation should intravascular insufflation occur.

Many high flow insufflators have a minimal default setting of 1L/min and *can be potentially dangerous for use in children.* I stress again the importance of choosing an insufflator with a low default setting of 100ml/min. Newer insufflators are available with an in built heater which could minimise heat loss in children.

The overall incidence of penetrating injury (Veress needle and trocar) is reported as 2.7 per 1,000 patients, but a recent survey found that nearly one-quarter of gynaecologists had experienced at least one case of Veress needle or trocar injury, with half of these requiring laparotomy.

Of 104 Laparoscopic related complications reported in adults in one year in an Australian state-wide survey, it is noteworthy that approximately 70% of visceral injuries were caused by blind Veress needle insertion alone. Blind Veress needle *and* blind trocar insertion combined are responsible for about 90% of visceral trauma.

Paediatric Complications

Moore & Peters reported 104 cases of laparoscopy for undescended testes and found the procedure non diagnostic in 8% due to extraperitoneal insufflation. Currie in a smaller group of patients undergoing diagnostic laparoscopy for undescended testes reported a 10% incidence of extra-peritoneal insufflation! They were lucky that they missed a major vessel. Schier reported 3 cases of major vessel injuries in 150 patients undergoing laparoscopic appendicectomy.

All extra-peritoneal insufflation reported in this series have all occurred with the use of the Veress needle. The Veress needle is a potentially dangerous technique and should be avoided in children as *the most serious complications occur from the use of blind puncture techniques.* The fact that the distance between the abdominal wall and the major vessels is barely 1 cm, together with the fact that the peritoneum in infants tends to strip off the anterior abdominal wall makes the insertion of a Veress needle potentially hazardous in a child.

Avoiding Trocar complications

Several steps should be taken to assure complication-free trocar insertion, the most important of which is to always observe the trocars going in *on the inside* via the endocamera. Even so, it is still possible to perforate internal viscera with the sudden loss of resistance when the trocar passes through the muscular layers, the so called OOPS factor! An added precaution to prevent this injury is to place the index finger on the shaft of the cannula as a guard, to prevent over penetration when the abdominal wall gives way.

The method of trocar insertion recommended for infant Laparoscopy will be demonstrated, and briefly involves creating a tract with a stab incision, and dilatation with a pair of mosquito forceps, so that the trocar can be inserted with minimum force.

Some paediatric laparoscopists advocate an even lower insufflation pressure than our current recommendation, but this creates difficulties with trocar insertion because of increased compliance of the abdominal wall to an advancing trocar. Sharp trocars will reduce the force necessary to penetrate the abdominal wall and is safer to use except in neonates because of the close proximity of viscera to the anterior abdominal wall.

Disposable Trocars

Disposable trocars have the added benefit of a safety shield which advances over the trocar once it has passed through the peritoneum. Nezhat recently compared disposable and standard reusable trocars, and found a significantly lower complication rate with disposable trocars. A study by Corson and associates demonstrated that disposable trocars required only one-half the force of introduction when compared to a regularly sharpened, re-usable trocar. Even so, penetrating injuries have been reported with safety shielded disposable trocars so they are not fool proof. They laxity of peritoneal attachment can also cause the safety shield to engage between the deepest layers of the abdominal wall and parietal peritoneum itself.

Bleeding

Bleeding has potentially serious consequences especially in paediatric laparoscopic surgery because of the much smaller blood volume, and brisk bleeding must be controlled quickly. Blood is also a very effective absorber of light in the peritoneal cavity. Much of the illumination in body cavities depends on reflected light from the surrounding viscera, and bleeding will very quickly results in loss of illumination from absorption of reflected light. This is especially so when one is using small telescopes, as light transmission is already limited by the smaller numbers of light carrying optical fibres.

Injury to the inferior epigastric vessels is *the* most commonly injury reported with trocar punctures in the lower abdomen. The absence of a Posterior Rectus Sheath in the lower abdomen does not allow any tamponade to occur, and bleeding will continue unless physically controlled. The inferior epigastric vessels however, are very easily identifiable as it funs along the peritoneum. It is best identified at its origin from the external Iliac vessels at the Internal Inguinal ring. always indent the overlying skin with a pair of mosquito forceps before inserting a trocar while watching the peritoneum to ensure that there are no major vessels immediately beneath the puncture site.

One should also make a habit of transilluminating the abdomen before puncturing the chosen site to ensure that there are no large sub-cutaneous vessels. Simple measures like these will minimise the risk of bleeding.

Control of abdominal wall bleeding
In inspite of these measures, when bleeding occurs, the following measures should be taken.

Tamponade
Minor bleeding can be controlled by inserting a larger cannula. Unless it is a major vessel bleed, this will tamponade the bleeding allowing you to continue with the operation. If this fails, insert a large Foley's catheter through the trocar site, inflate the balloon and apply firm traction and clamp the catheter against the abdominal wall with a artery forceps which will maintain the traction and tamponade. The Foley can be left in place for several hours.

Full thickness abdominal wall suture
Bleeding can also be controlled by passing a suture on a long straight needle through the full thickness of the abdominal wall, to one side of the bleeding vessel, passing it out on the other side, and ligating the vessel. You can form a figure 8 using this technique.

If all else fails, it will be necessary to perform an "open" operation to control bleeding. However, if the necessary preventative measures are taken as suggested in this section, then the risk of bleeding from the puncture site should be low.

Major vessel injury
In the unfortunate circumstance of a major penetrating injury to the aorta, common iliac artery or inferior vena cava, *do not remove the trocar.* Removing the trocar will only result in catastrophic bleeding due to loss of tamponade, and you will not be able to identify the puncture site. It is best to leave the trocar in situ and proceed to immediate laparotomy. You should then be able to follow the trocar to the site of injury and, hopefully control the bleeding and repair the damage. *Do not forget to check the opposite side of the vessel* as it is likely that the trocar will have gone through the far side of the damaged vessel.

Always be suspicious of major vessel injury if the retro-peritoneum if breached, and inspect the area from time to time for evidence of an expanding haematoma. Surgical exploration is mandatory if one sees an expanding haematoma.

Again, it must be stressed that most major vascular injuries are caused through blind Veress needle or trocar punctures and are avoidable with the Hasson technique and by monitoring each trocar as it is inserted.

Visceral bleeding
This can be difficult to control, and like most complications of laparoscopic surgery, is avoidable. Electrocoagulation will work with small bleeders. Alternatively, one can use an endoclip to control active bleeding.

However, one must always be aware of the surrounding anatomy. Diathermy control of bleeding may lead to unrecognised injury to the ureter or bowel, and the use of clips to control bleeding is a common way for common bile duct or hepatic artery injury to occur in cholecystectomy.

One can also place an "extra-corporeal" loop around the vessel, but be careful that the vessel is not avulsed in the process by pulling too hard on the loop during tightening.

Electrosurgical complications
Extensive use is made today of electrocoagulation in modern laparoscopic surgery, even though the early laparoscopic literature does not advocate this. However, the fact that it is a highly efficient and haemostatic tool of modern surgery means that it will continue to have widespread laparoscopic applications. It is therefore very important to understand how electrocoagulation works and how it can cause unrecognised damage, as there are now increasing numbers of potentially fatal complications of electrocoagulation being reported in the literature.

All modern diathermy machines have better control of output and built-in features to avoid return electrode faults which makes them safer. However, it is still possible to produce complications sometimes through obscure mechanisms, and it is therefore important to be aware of the complications which can arise from its use.

Electrosurgical i.e. burns, can occur at three sites, namely the active site (the active electrode), alternative sites, e.g.. ECG leads, stirrups, or at the return plate. Most modern electrosurgical units employing return electrode monitoring (REM) circuits have all but eliminated the risks of accidentally burns at alternative sites *with the exception of one situation,* and this is if a towel clip is clipped inadvertently through the active electrode and attached to skin.

Electrosurgical complications in laparoscopic surgery are most likely to occur with monopolar diathermy, and burns may occur in areas *outside* of the viewing field, by mechanisms not fully understood. These will be discussed in some detail later.

Active electrode burns
Direct inadvertent burns can occur in one of several ways: leaving the electrode in the body cavity while performing other tasks, or the electrode slipping during electrocoagulation and burning some adjacent viscera while the current is still flowing.

It is therefore very important to remove the electrode from the body cavity after using every time and to replace it in the insulating sheath in case someone accidentally steps on the diathermy control.

The Monopolar hook
This is a very good instrument for dissecting tissue planes, and the typical action is to hook tissue towards the surgeon while coagulating. This allows practically bloodless division of the intervening tissue. If however the hook suddenly gives through loss of resistance, (as it usually does when it has divided the intervening tissue) it is very easy for it to impinge on a neighbouring viscus such as bladder or bowel and cause an unrecognised perforation.

The monopolar hook should be used carefully and judiciously, e.g.. never hook towards a major vessel. Always be aware of surrounding anatomy, e.g.. vas, ureter and gonadal vessels in the paracolic gutter. A cardinal rule is that the diathermy tip should always be in full view when in use, well exposed and away from any metal cannula.

Remember that the current will also coagulate the base of any tubular structure if it is the only return path available. For example, holding the appendix up by its tip, to cut through the mesoappendix, may result in inadvertent burns to the base of the appendix, because the return current is concentrated at this point.

Vessels embedded in fatty tissue, such as mesentery, will retract into the fat and be difficult to localise, if they are cut before you have coagulated them. The best technique to use for monopolar diathermy is to place sufficient counter traction between the tissues being diathermied. As in open surgery, sufficient counter traction is the key to developing tissue planes.

Remote burns can also occur by less obvious mechanisms and these can be classified into three types: insulation failure, direct coupling and capacitive coupling.

Insulation Failure
The insulation may be damaged for a variety of reasons. If the insulation defect is small, it may be unnoticed and even a minute defect can lead to burns. A typical situation where burns may go unnoticed is if the defect is within a metal cannula, allowing current to leak from the defect to virtually any tissue, or the abdominal wall, and cause an unrecognised burn.

Direct Coupling
Another method of producing accidental burns is if the active electrode touches another *uninsulated* metal instrument, including the endoscope. Burns occurring via this route will occur outside the view of the surgeon, but if the cannula is all metal, the burn will be dissipated to the abdominal wall at the puncture site.

It is also possible for burns to occur by "direct coupling" if a metal cannula is not withdrawn sufficiently to expose the tip *and* the insulation, as the high voltage current has the capacity to jump across to the metal cannula to cause burns.

Capacitive coupling
Any radio frequency current flowing through a conductor will induce stray currents in nearby conductors, and this effect is termed "capacitive coupling". A capacitor is two conductors separated by an insulator.

In laparoscopic surgery, it is easy to create a capacitor using the active electrode as one conductor, and a nearby metal cannula or grasper as the second electrode. If one conductor carries a charge, an *equal* and opposite charge is induced across the insulator to the second conductor, which in this case would be the nearby metal instrument. This phenomenon occurs frequently in electrosurgical cautery. Under certain conditions, these stray currents can cause burns typically outside of the viewing area of the endoscopist.

These stray currents are maximal if the active electrode is energized on an open circuit, i.e.. when the tip is not in contract with tissue *and full power may be delivered* through the second unintentional electrode even though it is not in direct contact with the active electrode. When the active electrode is in contact with tissue however, the induced stray current is markedly reduced but not completely eliminated. *Hence it is not safe to activate the active electrode unless it is in direct contact with tissue.*

Bipolar Diathermy
Bipolar diathermy is by far the safest method of achieving haemostasis but suffers from the fact that one often has to interchange the bipolar forceps with a pair of endoshears to cut through tissue. However as recently designed pair of forceps is able to coagulate and cut at the same time and will make Bipolar diathermy much more easy to use.

Visceral Injuries
Other visceral injuries such as bowel perforation, injury to the urinary tract, or damage to the vas have all been reported. Most of these injuries are preventable.

Bowel injury
Bowel injuries occur most commonly with blind punctures, but have also been reported from diathermy burns and the use of laser. The risk is increased in patients with previous open surgery, where bowel may be adherent to the under surface of previous abdominal incisions. Many paediatric exploratory laparotomy incisions are transverse supra-umbilical incisions so special care has to be taken with the Hasson technique of introducing trocars.

It may sometimes be necessary to enlarge the Hasson incision sufficiently to insert a finger, and sweep adhesions aside or alternatively, to make a mini-incision well away from the site of previous surgery.

Diathermy burns may be more extensive than their superficial appearances. Minor burns or lacerations may be managed conservatively. Small perforations may be oversewn, but larger ones probably require open surgery, although with endostapling techniques it is technically feasible to resect and reanastomose bowel entirely laparoscopically.

Wheless reported on bowel injury in 33 patients. In the first six cases in which a burn was seen endoscopically, a perforation was identified in only two patients at open laparotomy. The next 27 were all managed completely conservatively and none required laparotomy subsequently.

Bowel injuries are often unrecognised at the time. However, the appearance of succus entericus or a faeculant odour should alert one to this possibility if this occurs during laparoscopy.

Unrecognised bowel perforations present three to seven days postoperatively with abdominal pain, pyrexia, and ileus. However, it can be difficult to eliminate the possibility of bowel injury in patients recovering from severe appendicitis when the appendices has been removed laparoscopically, but failure to respond to antibiotics, or deterioration in clinical signs, would indicate on-going mischief.

Urinary tract injury
Bladder and ureteral injuries have been reported mostly with pelvic surgery. However, there is a greater risk of bladder injury in children because the bladder is an intra-abdominal organ. Emptying the bladder before laparoscopy will reduce this risk. Be aware that the Urachus is prominent in infants, and its extension to the umbilical cicatrix could still be patent. Infra-umbilical cannula placement, even with the bladder emptied, could therefore still lead to bladder injury. The best way of avoiding this is to watch the tip of the trocar during insertion into suprapubic sites.

Small defects from Veress needle punctures may be managed conservatively with urinary catheter drainage, but large injuries should be oversewn laparoscopically. A urinary catheter should be inserted for postoperative drainage.

Ureteral injuries
These are often unrecognised and may present as an acute abdomen or urinary ascites. If the injury is identified intraoperatively, it can be repaired. Small defects can be managed with stenting.

Unrecognised ureteral injury presenting in the postoperative period require intravenous urography to confirm the diagnosis. These can be managed with a retrograde insertion of a double pigtail catheter, but if this is difficult, a percutaneous nephrostomy should be performed to allow the situation to resolve. A nephrostogram can then be performed at a later stage to assess the full extent of ureteral injury, and an antegrade double pigtail catheter can still be inserted to stent the ureter. Often, proximal drainage is all that is required.

Ventral Hernia
Ventral hernias have been reported particularly with the use of a large trocar and cannula. We have always closed the 10mm trocar with a purse string suture to prevent this; small secondary cannula sites can be safely opposed with steristrips closure. A new suturing devise to close trocar sites is now available.

Postoperative umbilical hernias have been reported, especially in premature infants if the cannula is inserted through the umbilical cicatrix. It is for this reason that we recommend making the Hasson is inserted in the Linea Alba.

Other hidden dangers
There is a considerable amount of new technology appearing on the laparoscopic scene, and one must approach the introduction of some of these technology with some caution.

Lasers
While lasers may be useful in Laparoscopic surgery several deaths have been reported recently from the use of Laser and most of theses deaths have been due to user error. It is important to realize that some Lasers require a backstop, while some require a large volume of a cooling gas such as Nitrogen which in itself can cause problems when insufflated into a small abdominal cavity.

Argon Beam Coagulator
The Argon Beam Coagulator or ABC likewise also suffers from the need to pump a large volume of Argon into the abdomen for it to be effective. This can cause a marked increase in the intra-abdominal pressure and is therefore largely unsuitable for use in children.

Conclusions
It is clear that most complications are preventable by a better understanding of the capabilities and limitations of your equipment, and also of the capabilities and limitations of *yourself.*

Vascular and visceral injuries are largely preventable by using the Hasson technique for introducing the primary trocar and cannula, and by directly viewing the introduction of all secondary trocars.

Most of the major complications also occur during the learning curve. Remember that most paediatric open operations have such a low morbidity that it is difficult to justify the introduction an alternative technique which might be seen to be unsafe, or one that causes too many complications during its introduction. it is best to begin with simple diagnostic procedures until you are completely familiar with the technique and equipment before performing some of the more complex procedures which will be demonstrated at this workshop.

TIPS ON SAFE LAPAROSCOPY

1. Check all instrumentation, video equipment, gas supply, diathermy etc. before starting operation.

2. Start with simple procedures.

3. Convert to open procedure if unsure. It is no shame to convert.

4. Keep patient warm.

5. Always use Hasson technique.

6. Always introduce secondary trocars under direct visual endoscopy.

7. Avoid insufflators with high default settings.

8. Do no open jaws of instrument blindly within any body cavities unless you can visualize the tip.

9. Avoid monopolar diathermy unless you are well aware of the risks of capacitive coupling and have taken measures to avoid them.

10. Only use lasers with appropriate backstops etc.

H L Tan

THE ERGONOMICS OF LAPAROSCOPIC SURGERY

Hock Lim Tan

Ergonomics is the study of people at work or in other structured activities. It is applied to equipment design, environment, the design of user friendly computers etc.., and has an important role in laparoscopic surgery. It is very important to understand the ergonomics of laparoscopy because unlike conventional surgery, laparoscopic surgery is not intuitive. The general principles used in open surgery in relation to patient positioning, exposure and the floor plan (position of the surgeon, assistant and scrub nurse), may be completely inappropriate when applied to laparoscopic surgery. Understanding laparoscopic ergonomics therefore makes for easier surgery.

Eye hand coordination & Paradoxical movement

Laparoscopic instruments have to be inserted through an instrument port and work around a fulcrum. Hence instruments moved in one direction by the surgeon will be seen to move in the opposite direction both horizontally *and* vertically. This is first order paradoxical movement and one can get used to this in a few minutes, as it is no different from rowing a boat. This however only applies in the situation where the endo camera is pointing straight ahead, and the video monitor is placed *directly in front of the surgeon.*

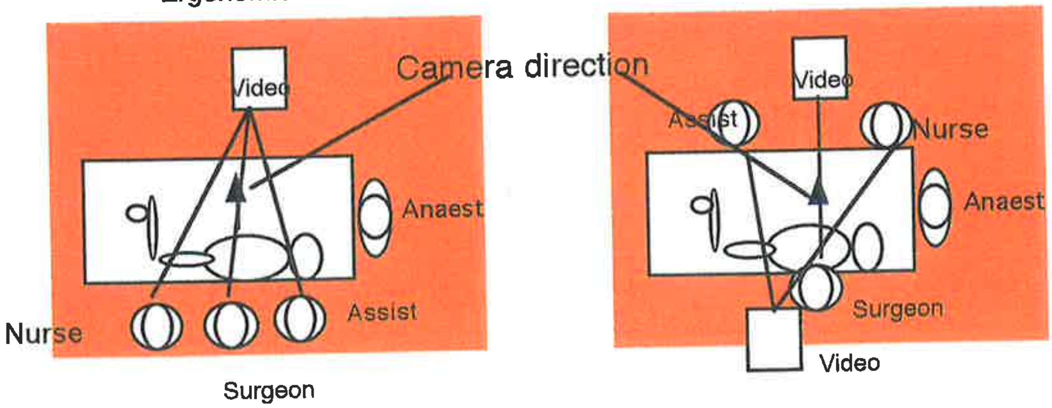
If on the other hand, the endocamera is pointing towards to surgeon, a left to right movement by the surgeon will also be seen as a left to right movement on the video monitor i.e. the sideways movements is *not* paradoxical and yet the vertical movement continues to be. In other words, the horizontal axis is now reversed, and a second degree of paradox is introduced, and much like driving using the rear view mirror, many simple tasks then become much more difficult and sometimes impossible if this second order paradox is introduced into laparoscopic surgery.

This problem of displaced visual coordination has been studied by Kohler in 1939 where he and other experimental subjects wore reversing prisms on spectacles for days or weeks at a time. They reported "days or weeks were spent in correcting movements disturbed by the reversal, some of which were incorrectly repeated hundreds of times." In cases where left and right were reversed, someone trying to walk along a straight path would lurch from side to side like a drunk.

Most surgeons intuitively recognise this and place themselves in an optimum position, so that they are correctly aligned with the camera and video. This is however, *not* the case commonly with regards to placement of the assistants, as it is quite a common practice to position the assistant or scrub nurse *opposite* the surgeon, working against the camera with a second video monitor placed directly in front of these assistants. They are now forced to work in second order paradoxical movement .

Typical Layouts for laparoscopic nephrectomy

Ergonomic | Non Ergonomic



Note: Surgeon, Assistant and Nurse are all in correct line of Vision in relation to Endocamera. All are in 1st order paradox

Note: Assistant and Nurse are both working *against* Endocamera ie: 2nd order paradox

It is quite common to see an assistant positioned opposite the surgeon as illustrated in the right side figure. This is *not* ergonomic because they are now working in second order paradox i.e. working *against* the camera. The only way the assistant and OR nurse in the picture on the right can control instruments is by deliberately thinking about their movements each time. This can be a potentially dangerous situation particularly if quick or fine movements are required e.g. in controlling bleeding or endosuturing. It is impossible to suture let alone cut a suture in this position.

Ergonomic rules:
Surgeon assistant and scrub nurse must be on the same side
The video monitor must be straight ahead, and camera pointing towards to monitor.
Never use more than one video monitor

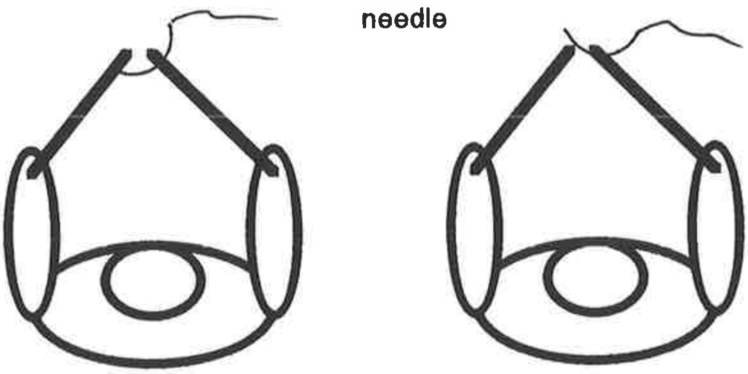
Restriction on freedom of movement

There are six degrees of movement in conventional surgery, but laparoscopic surgery only allows four degrees of movement i.e. lateral, vertical, in-out and rotational (around the axis of the instruments). This places important limitations on the ability to perform certain simple tasks such as seeing around corners, and especially endosuturing.

Seeing around corners is not possible but there are ways around this namely:
Angled scope. The 0 degree scope is best for most applications, but a 30^{o} or 70^{o} scope can be useful when one has to see around a corner. However, remember that your perspective is changed yet again and some parallax error can occur in your movements.

Endosuturing

One of the most challenging and difficult aspects of laparoscopic surgery is endosuturing, but becomes easier if you to take into consideration the fact that suturing has to be performed around a fulcrum, and the laparoscopic instrumentation is always introduced at an oblique angle. This means that holding the needle in the jaws of the needle driver at 90° *may not be the best position,* and I prefer to hold the needle at 30° which is more ergonomic.



Incorrect Correct

Most of us suture at open surgery by running along the line of the anastomosis. It is difficult even in conventional open to suture across this line, and yet this is a common practice in laparoscopic surgery. The key to laparoscopic suturing therefore is to consider the line of the anastomosis, and *to place the suturing port in a position which allows you to suture along and not across the anastomotic line* . This is a simple and most frequently broken rule, which if not adhered to makes for very difficult laparoscopic suturing.

Lack of tactile feedback

Although there is lack of normal tactile feedback, there are many visual and non visual cues that can alert one to the possibility of impending danger or tiger country thus avoiding disasters arising from the "OOPS!" factor.

Counter traction is probably the most important dissecting technique in laparoscopic surgery especially when using diathermy. Tissue tends to contract towards a diathermy electrode and stick to it unless counter traction is applied. This is potentially dangerous and can cause charring or inadvertent perforation of adjacent structures. Maintaining adequate counter traction at all times will assist in developing the tissue planes and prevent this contraction of tissue towards the electrode. When using diathermy to dissect a tissue plane, the electrode should always be directed away from important structures in case of the *OOPS!* factor.

Visual cues in laparoscopic surgery

Loss of stereoscopic vision results in reduction of several important visual cues, particularly depth and spatial relationships. However, sometimes this can be sacrificed in favour of magnification, and this is particularly true of laparoscopic suturing, where with practice, one can be more precise with suture placement than with conventional suturing using the naked eye.

The dynamic view achieved by moving your head from side to side to capture the spatial relationship is lost in laparoscopic surgery, but several cues can be used, and the one commonly used by most laparoscopic surgeons are:

Exploratory movements and touching organ with the instruments where gentle prodding and circular movement will help identify the position of the structure in relation to the instruments.

Gestalt i.e.: Observer's own mental picture of the anatomy is one of the most important cues and can only come from experience. One must remember that the laparoscopic perspective of anatomical relationship can be quite different from your normal perspective at open surgery.

Light intensity: The further away the organ is, the dimmer is the light.

Relative size: ie. the smaller it is, the further away the object. Do not forget that the endoscope provides magnification when brought close to the target organ, and this can often mislead one into thinking that a little blood loss is catastrophic. Faced with such a situation, always pull the telescope away from the operative field, as this gives you a truer perspective of the degree of bleeding, the situation very often looking much less catastrophic than when magnified by a close up look.

Detail perspective. The surface texture of the organ fades the further away. By the same token, bringing the telescope close up to the object will allow almost microscopic view of fine structures, and can facilitate fine endosuturing.

Triangulation is an important principle in laparoscopic surgery, and the angle of the operating instruments will give you an appreciation of the depth of the structure.

The spatial relationship and triangulation is lost with each interchange of instruments, and it is not uncommon for a laparoscopist to spend some time after each instrument interchange to re-locate the instruments. This is extremely time wasting.

Most surgeons withdraw the telescope to locate " lost instruments". If your telescope is *in front* of your instrument ports, it stands to reason that it is impossible to locate the instrument no matter how far you pull back on your telescope.

It is important therefore to try to keep your scope behind the instrument ports at all time so that if you have to withdraw the telescope to locate the instrument, the instrument port will be within your field of vision.

Gestalt is most useful. By remembering the spatial position of instruments, and holding the instrument cannula in its correct spatial position during interchange of instruments, the new instrument will follow the same path and you will not have to keep searching for lost instruments. It is important when interchanging instruments to keep your eye on the Video monitor at all times and let your assistant do the interchange, otherwise you may insert the instrument too far and cause visceral damage.

Port placement

In conventional surgery, all surgeons place our incisions as close to the target organ as possible e.g. a RIF incision for open appendicectomy. No one places an appendicectomy incision in the left upper quadrant of the abdomen for obvious reasons. There is therefore a tendency in laparoscopic surgery to position instrument ports close to the target organ as well, because of our experience in open surgery.

Unlike freehand surgery however, consider that movement at laparoscopic surgery is limited by the fulcrum at the abdominal wall which serves as the point of entry for your instrument ports. Apart from restricting the degrees of freedom of movements, there are several other important ergonomic considerations:

If your working port is too close to the target organ, your ability to manipulate your instruments will be limited because there is less room to work, the operative field being limited to a volume approximating a cone with the apex at the point of entry of your instrument port. Furthermore, if your instruments are too close to the organ, your *external* movements are exaggerated, you have to operate with your arms wide apart like an orchestral conductor and this becomes tedioscopic surgery!

Placing the instrument ports further away from the target organ allows more room for movement. However if your instruments are too far away, then the viscera may be out of reach and all *internal* movements will be amplified or exaggerated making fine manipulation difficult.

It is best to place the instrument ports so that the fulcrum is approximately half the working length of the laparoscopic instruments i.e. Half in, half out!.

Gravity and its role in endoscopic surgery

Gravity can be your friend or foe. If the patient is positioned correctly, the viscera will retract away from your operative field and can be your friend. However, if you position the patient such that the viscera flops into your operating field this makes your surgical exposure difficult.

A simple example of this is that if you place a patient in Trendelenburg position, the bowel can be retracted easily away from the pelvis, and this makes for easy exposure to the pelvic organs in contrast to the opposite direction which makes it virtually impossible to gain adequate pelvic exposure if the viscera can not be retracted out of the way.

However organ retraction is not the only consideration. Haemostasis is important. If the operation field is in the most dependent position, blood or fluid will pool around your operative field. Should bleeding occur, it will also be difficult to locate the bleeding site within a puddle of blood.

Try to position the patient so that the viscera you are operating on is in an elevated position so that blood and fluid will drain away giving you a better chance to have a clean operating field, and better control of haemostasis.

Summary:

Ergonomics is the study of people at work or in other structured activities. It is applied to equipment design, environment, the design of user friendly computers etc.., and has an important role in laparoscopic surgery. Adopting an ergonomic approach to laparoscopic surgery will remove much of the frustration of laparoscopy. It is also an integral part of designing a new operation, and if these principles are adhered to, then one is more likely to plan and get a new operation right at the beginning. Using these principles, I have only had to make very minor modifications to port and patient positioning for each new procedure that I have developed.

The "TAN commandments!

Do not open and close instrument jaws within the body cavity unless it is in direct view of the camera.

Be careful when dissecting adherent structures or difficult tissue planes. Difficult tissue planes often means no surgical plane, and trying to develop this non existent plane could invite disaster.

Be thoroughly familiar with the anatomy.

Sharp, haemostatic dissection is best. Blunt dissection has little role in laparoscopic surgery.

Like purchasing real estate, the three basic rules are position, position, position that is:

patient position. This is especially critical if you have to perform intra-operative X-rays. Check that the C arm of the image intensifier can be position correctly when it is required and do a stat film to ensure that there is not a radio-opaque metal bar, ECG button etc. right over where you want to image.

surgeon' position ie: position yourself and assistants correctly

Port position: position your instrument ports correctly

Always check your hardware i.e. insufflator, light source, video camera, video recorder are in working order before you start operating. There is nothing more frustrating or dangerous than to find out that your light source is out of order after the patient is anaesthetized and draped.

Conclusion

This thesis documents some of the progress made in paediatric endoscopic surgery through my own clinical applications, basic research, and innovating new techniques. Unlike adult general surgery, where the impact of laparoscopic cholecystectomy was explosive, the progress and development of endoscopy has been more gradual and muted even though paediatric surgeons have long been adept at perform diagnostic endoscopies particularly cystoscopy, bronchoscopy and esophagoscopy to diagnose and manage simple intraluminal pathology. Therapeutic advances in paediatric surgery has always been limited by the lack of miniaturised equipment until recently and as a consequence, advances in paediatric endoscopic surgery has been relatively late in coming.

It is clear from this thesis that while significant advances have been made in the management of many adult conditions such as renal calculi, much of the instrumentation available to manage adult surgical conditions may not be suitable for paediatric patients with unless significant modifications are made to the technique or equipment.

For example, while it is possible to use extracorporeal shock wave lithotripsy (ESWL) to manage older children with renal calculi, there is significant risk of lung trauma unless the lung is protected from the externally generated shock wave by wrapping the patient with polystyrene foam.

Similarly, while one can use an adult nephroscope through a 28Fr Amplatz sheath to perform Percutaneous nephrolithotripsy, it is not without significant risk of bleeding and of splitting a small kidney. It is for these reasons that we evaluated the risks of these procedures in young infants.

The areas that I have contributed to, and which are included in this thesis on paediatric endoscopic surgery includes:

The refinement of paediatric endoscopic equipment.

Much of the instrumentation developed for adult endoscopy is too big and cumbersome for use in children, and many modifications have had to be made to the equipment.

Modifications to the PCNL equipment, especially the adoption of an infant cystoscope for nephroscopy has eliminated the use large of Amplatz sheaths. We now perform PCNL using 14 French Amplatz sheaths as opposed to our earlier experience with 28 French sheaths.

Paediatric laparoscopic surgery likewise, began in a similar manner. There were no paediatric laparoscopic instrumentation available right at the onset. It was at my instigation and persistence that we developed a new paediatric operative laparoscope set with Karl Storz, and this was accomplished not so much by asking the instrument makers to make a completely new line of instruments. Instead, it was achieved by adopting and adapting existing technology. By scouring the complete Karl Storz we successfully adopted and adapted various pieces arthroscopic, gynaecological and ENT equipment for paediatric laparoscopy. An example of this is the adoption of a 4mm 0 degree arthroscope as an infant laparoscope. Likewise the "Tan" endotome as used for pyloromyotomy for infantile hypertrophic pyloric stenosis is a direct descendant of an arthroscopic knife!

New paediatric endoscopic operations

We have demonstrated that the laparoscopic bipolar "strip tease" technique as described for appendicectomy can be developed as an extension of a novel open technique, but this requires the production of an equivalent instrument such as a laparoscopic needle point Adson's forceps now known as the "Tan" bipolar forceps.

It is relatively easy to justify performing procedures such as laparoscopic appendicectomy or fundoplication in children when a precedence has already been set by the adult surgeons who have demonstrated that these operations can be performed laparoscopically, and safely. In other words, it is easier to copy what has already been done in adult surgery and adapting it to paediatric surgery than to invent a whole new operation. This is generally true of all kinds of surgery whether it be adult general or paediatric surgery.

Developing a completely new laparoscopic procedure, one which has not been performed by anyone else however, is a completely different issue. A prime example of this is laparoscopic pyloromyotomy for infantile hypertrophic pyloric stenosis.

It is not so easy to justify performing this operation laparoscopically when a simple and effective operation already exists, particularly when experience with laparoscopy in the neonate was so limited. The only way that these operations can be developed is to prove that laparoscopic surgery can be performed safely and with very minimal morbidity first.

Hence it is noteworthy that while my experience with paediatric endoscopic surgery dates back to 1986 beginning with paediatric endourology, it had to take several more years before I would even consider venturing into a laparoscopic pyloromyotomy, as it was necessary for me to prove that I was a safe and skilled endoscopist.

Even so, my report on laparoscopic pyloromyotomy was met with considerable scepticism when it was first presented and subsequently published, the usual comment being why bother? It is noteworthy however, that this initial resistance to laparoscopic pyloromyotomy even from my other paediatric laparoscopic surgeons and trusted colleagues is now met with enthusiasm. My colleagues, who were initially critical of this operation are now performing this operation and are advocating laparoscopic pyloromyotomy as the operation of choice. There is now evidence to demonstrate that this is as safe as, and may well be a superior operation to open surgery.

In the area of paediatric endourology we have demonstrated that procedures such a percutaneous nephrolithotripsy can be performed safely in children. We have also reported that percutaneous pyeloplasty or pyelolysis can be equally effective in children as in adults. However, the demand for results that match the gold standard for UPJ obstruction i.e. dismembered pyeloplasty means that it is improbable that endopyelotomy will gain widespread acceptance as the treatment of choice for managing uretero-pelvic junction obstruction, particularly when it has a steep learning curve.

On the issue of uretero-pelvic junction obstruction, we have demonstrated the ability to perform laparoscopic Anderson-Hynes dismembered pyeloplasty with results approaching that seen with open surgery. The criticism that it is too difficult an operation to perform and that it takes too long has also been addressed. The technique developed of utilising a "Hitch stitch" to stabilise the renal pelvis in order to perform fine laparoscopic suturing has not only reduced the time required for performing the operation, it has also considerably simplified endoscopic suturing. Laparoscopic Anderson-Hynes dismembered pyeloplasty however, still requires a very high level of skill to perform an adequate micro-anastomosis with 6/0 PDS.

Having evaluated all three methods of managing the uretero-pelvic junction, that is endopyelotomy, retrograde radial balloon dilatation and laparoscopic dismembered pyeloplasty, it is believed that that almost all cases of uretero-pelvic junction obstruction in childhood can now be managed without open surgery. Only the very young babies present with a management problem, as the only two failures in the group of patients undergoing laparoscopic dismembered pyeloplasties were both operated on when they were three months old. With improved retrograde balloons become available, it may be possible to overcome problems in this group as well.

We have demonstrated that complex procedures including laparoscopic adhesiolysis, cysto-prostatectomy and dismembered pyeloplasty can now be performed with safety in young children

The future of paediatric endosurgery

There is no doubt that paediatric endosurgery is here to stay as an increasing number of institutions and authors report that they are able to perform complex procedures such as laparoscopic pull through for Hirschsprung's disease, fundoplication and laparoscopic Anderson-Hynes dismembered pyeloplasty with good results. It is gaining acceptance as an alternative to conventional open surgery.

Further development in paediatric endosurgery however, requires that more paediatric surgeons train in and become adept at endoscopy. Unless this occurs, complex paediatric endoscopic surgery will remain in the hands of a few surgeons skilled at the operations, and will not gain widespread acceptance.

Training more paediatric surgeons in endoscopic surgery is, I consider, now an important priority as sadly, it is generally accepted that paediatric surgeons lag behind adult general surgeons. At this present time however, there are probably no more than about six to ten centres worldwide than can offer adequate training in paediatric endoscopic surgery.

I would like to address this in my concluding remarks.

Training in paediatric laparoscopy

Unlike general surgery, we do not have a gall bladder to practice on. Most general surgeons cut their laparoscopic teeth on cholecystectomy but unfortunately, this is uncommon in children. In general there are not many common conditions on which a paediatric surgeon can practice his skills. Instead, one has to rely on a wide variety of often complex cases to hone skills on, and herein lies the problem:

How does one become good at laparoscopic skills as a paediatric surgeon when there are fewer cases which are often complex requiring a higher level of skills than required to perform laparoscopic cholecystectomy? It would be unusual for a paediatric surgeon to perform more than one laparoscopy per week unless one is especially focused as is in my case.

This is a problem that I have been addressing over the past few years, and experience with conducting regular workshops in paediatric laparoscopic surgery has lead me to conclude that it is not necessary to perform a large number of cases all the time to maintain one's laparoscopic skills. Instead, it requires a very high level of training.

I believe that this is akin to the training of commercial airline pilots, where they are rarely if ever called on to extinguish a fire in a jet engine and yet when called upon to do this, are well prepared and trained, even though they may never have done it before in real life.

It is an observation however that surgeons, even those attending so call advanced courses, are only keen to learn specific operations, and have no interest in learning the basic principles that are essential.

In spite of these shortcomings, I hold the view that laparoscopic workshops for the moment, is the cornerstone for the training of paediatric laparoscopic surgeons. The topics covered a these workshops cannot be addressed in any scientific program and is best taught as a structured didactic lecture.

One of the topics taught is how to use and trouble shoot endoscopic surgical equipment. In otherwords, understanding the surgical hardware required in laparoscopic surgery. Unlike general surgery when the endoscopic equipment is in constant use and well maintained by the operating theatre staff, this is not the case in paediatric surgery. There is rarely a dedicated team of nurses and technicians trained and available to set up and maintain the equipment. Most operating theatre staff in Children's hospitals are in fact not at all familiar with endoscopic equipment with the result that there is often mismatch of instruments and many other "nuts and bolts" issues which makes for difficult endoscopy.

Having experienced all these difficulties, I now believe it is essential for the paediatric endoscopist to know all about his surgical hardware, the video equipment, insufflators and everything else that matters, as no one else in the operating theatre will know how to fix the problem if you do not know how to do it yourself.

The majority of paediatric surgeons, even those reasonably skilled in basic laparoscopy, do not understand that laparoscopic surgery is not intuitive and that it is necessary to understand the fundamentals of first order paradoxical movement, ergonomics and how it relates to eye-hand co-ordination.

To emphasise the importance of understanding ergonomics, in addition to the lecture notes on ergonomics of laparoscopy, work stations are available in all my laparoscopic workshop to demonstrate that even the simplest task is often rendered impossible if the laparoscopic instruments are incorrectly set up ergonomically. These workstations are highly effective in demonstrating the importance of understanding ergonomics.

The last issue is one of safety. There is considerably less margin for error in paediatric endoscopic surgery. Whether it be endourology where a small infant may be at risk of massive fluid load if one is injudicious about the use of the irrigating fluid, or in laparoscopy where the use of high flow insufflators pose significant risk of hypothermia, safety is of primary importance and this is stressed at my workshops.

The best way to avoid complications is to know about them and how they arise. For that reason, complications of laparoscopic surgery is heavily featured in my laparoscopic workshops. The complications of electrocoagulation is emphasised as this is probably the commonest avoidable complications.

In conclusion, paediatric endosurgery is here to stay. Although the benefits afforded to children are less tangible than seen in adult population, it is gaining popularity. There is evidence available today to demonstrate that there are real benefits of endoscopic surgery to children. There is also increasing parental demand for less invasive surgery.

However the over riding concern must be "first do no harm". It is becoming clear that endoscopic surgery in fact does less harm to children than open surgery, This thesis has outlined some of the developments and contribution made to paediatric endoscopic surgery.